World War I Battlefield Artillery Tactics

DALE CLARKE

ILLUSTRATED BY PETER DENNIS

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Series editor Martin Windrow

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WORLD WAR I BATTLEFIELD ARTILLERY TACTICS

INTRODUCTION

Artillery was the single most important element of 'combat power' in the land warfare of 1914–18, and many of the most important advances in military science during the war were responses to the artillery battle. The guns used were, to a great extent, those that were available at the outbreak of hostilities; but the ways in which they were employed – artillery tactics – evolved during the next four years to an extraordinary extent. From dashing battery actions in summer 1914, which were essentially Napoleonic in their tactical character, within two years an 'industrial' artillery was physically reshaping the battlefields of the Western Front, and by 1918 artillery

The battlefield literally reshaped by artillery fire: the village of Beaumont Hamel on the Somme in November 1916, after its eventual capture by British troops. (Imperial War Museum Q1558)

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LEFT Typical of the rifled, breech-loading pieces produced following the Franco-Prussian War was the German Foot Artillery's Krupp *9cm C/1873 Kanone*, with a horizontal sliding-wedge breechblock; the black-powder propellant charge was fired by means of a friction primer inserted in a vent on top of the breech. This generation of ordnance were acquired by many armies, but were outclassed by the appearance of the quick-firing, long-recoil French 75mm M1897 gun with fixed, smokeless ammunition. Nevertheless, the C/1873 was still in service with some German territorial reserve units in World War I. (Author's photograph)

techniques of unprecedented sophistication were fully integrated into the all-arms battle plan. Naturally, a book of this size can only give a broad overview of this transformation, concentrating on the major combatant armies and some of the most important battles.

The consequences of that transformation would be enormous, since the years 1917–18 saw a fundamental shift in the conduct of warfare. Historically, battles had been physical encounters between armies, each manoeuvring to gain advantage and supported by direct artillery fire, frequently at very short ranges. The battle of Cambrai in November 1917, and the *Kaiserschlacht* offensive in the spring of 1918, heralded the arrival of a new kind of warfare – the 'deep battle' – which was seen thereafter throughout World War II and the remainder of the 20th century.

The 'deep battle' is three-dimensional, and takes place over a wide area. Battle planning emphasizes tempo and simultaneity, and is based on an understanding of the enemy drawn from a range of intelligence sources. The plan seeks to achieve a rapid penetration by manoeuvre forces, and the collapse of the enemy's cohesion. It depends on commanders at all levels understanding the force commander's overall intention, and acting, where necessary, on their own initiative to overcome unforeseen threats and obstacles and to seize unexpected opportunities. In the deep battle artillery plays its part in deception; in the direct preparation for the breakthrough; and in 'offensive support', using indirect long-range fire to shock and dislocate the enemy by hitting headquarters, logistics and communications, by blinding observation, preventing enemy artillery from responding, and destroying reserves. It seals off the battlefield, stopping the enemy from moving forces in or out. The deep battle would remain the model for at least the next 100 years; it would, however, have been entirely unrecognizable to the armies of 1914.

RIGHT German *Rundblickhemrohr (Rbl) 16* panoramic artillery sight manufactured by Carl Zeiss. The Germans were quick to learn from an innovative 1882 Russian manual on indirectly aimed fire, and to produce their first panoramic gunsights. Experience in South Africa persuaded the British that the technique was unsuitable for field artillery, but by 1913 they too had followed suit. Used on the *10.5cm leFH 16* light field howitzer in World War I, this particular sight continued in German Army service into World War II. (Photograph Ben Clarke)

EQUIPMENT & TACTICS *c.*1900–1914

By the opening of the 20th century the artillery of the major European armies had been shaped by a generation of scientific and industrial advances so rapid that they had overtaken the military's attempts to develop doctrine to exploit them to best effect.

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To support infantry and cavalry in battle, all the major powers had mobile, horse-drawn, breech-loading (BL) rifled field guns with ranges of about 6,000 yards. High explosive (HE) shell fillings based on picric acid (the German 'shell filler 88', French 'Melinite' and British 'Lyddite') were about to be replaced by the more stable and effective trinitrotoluene (TNT), but tactical doctrine for manoeuvre warfare placed more importance on shrapnel shells. Newly accurate time-delay fuzes burst these above and in front of enemy troops to lash them with hundreds of metal balls in a deadly 'shotgun' effect. This, together with the long accurate range of modern rifles, would prompt armies to introduce new open-order infantry tactics. Simultaneously, new nitric acid-based propellants for small arms and artillery were virtually 'smokeless', which made enemy troops and gun positions far more difficult to locate in action. These changes would produce the phenomenon of 'the empty battlefield'. No longer could roundshot and canister plough bloody furrows through massed enemy ranks; gunners now had to engage indistinct, dispersed targets at ranges of thousands of yards, while themselves under long-range fire.

Indirect fire

The new long-range weapons had made the use of artillery from behind cover, often against targets not physically visible from the gun line, more urgently necessary. Between the 1880s and 1914, all the major European armies and the US Army adopted an indirect-fire system for using aiming points on which to set the guns' sights, and observers at a distance to observe the fall of shot and pass corrections. Panoramic sights were set on a distant but clearly visible 'aiming point' (e.g. a church steeple), or on a line marked by aiming posts. The angle between the gun-aiming point line and the gun-target line was calculated, and set on the sights; with the sights aligned on the aiming-point, the gun was now pointing at the target. Range was set on a drum on the gun carriage, and the barrel was elevated or depressed until the correct markers were aligned. By 1914 indirect laying was in fact the normal method for aiming artillery regardless of the intervisibility of gun and target.

The obvious benefits of guns being able to fire from behind cover, and engage targets in 'dead ground' at long range, were offset by the difficulty of communication between a remote forward observer and the gun battery. The adoption of various forms of visual signalling for remote controlling of the guns culminated in the introduction of field telephones, but in manoeuvre warfare the laying and recovery of telephone wire was a practical nightmare, and the first-generation

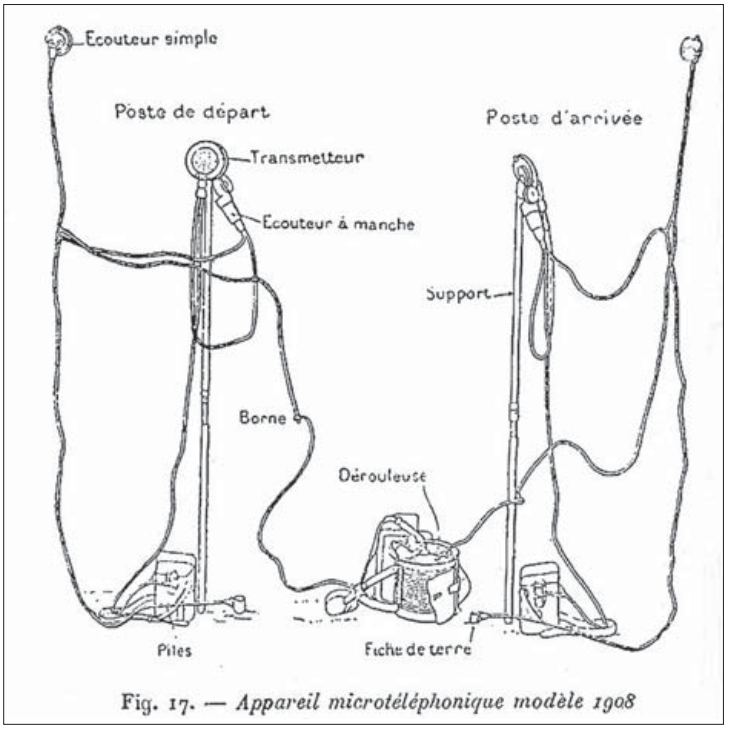

Fig. 17. — *Appareil microtéléphonique modèle 1908*

Telecommunications would transform the battlefield, particularly for the artillery, but early equipments like this French M1908 field telephone were complicated, fragile and inefficient. The transmitter microphones are mounted on extending poles, to which two receiver earphones are linked by cables. The *dérouleuse* or spool (bottom centre) allocated to the artillery battery held only 500m of wire, which was quite inadequate. (Author's collection)

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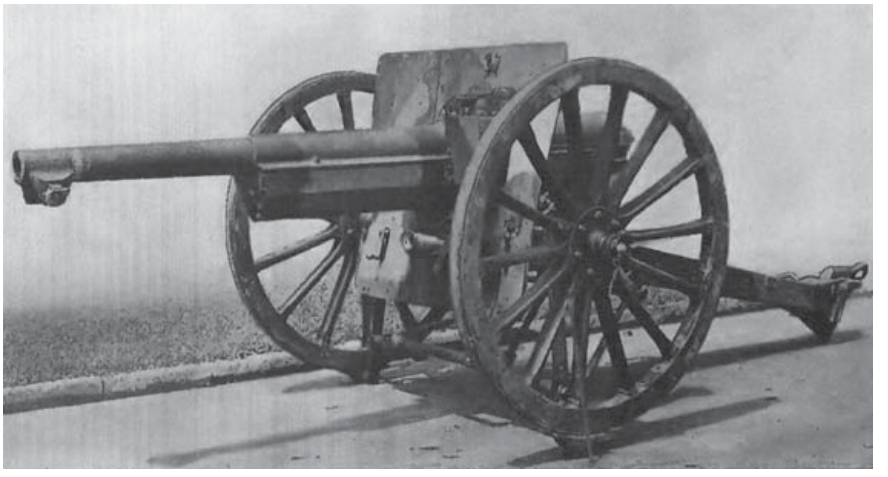


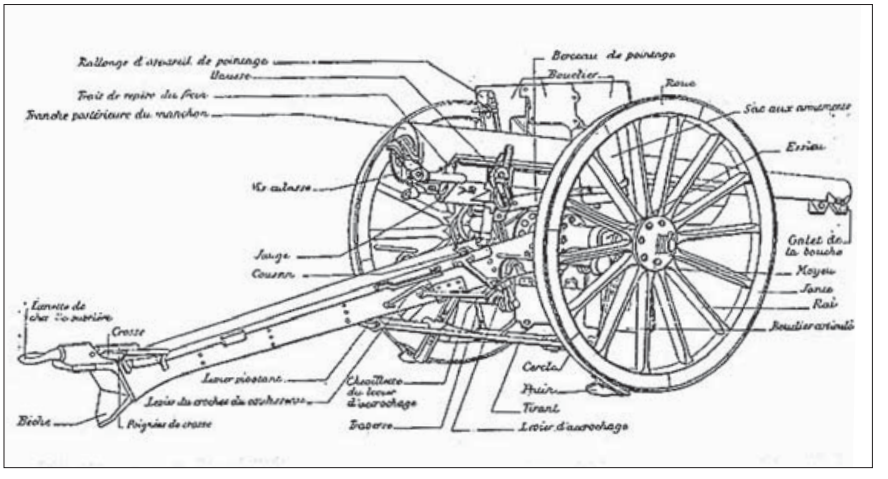
The French 75mm Mle 1897 QF field gun, here illustrated in a US Army technical manual. Note that the brakes are deployed under the wheels, effectively turning the carriage into a fixed tripod on which the long barrel-recoil mechanism ensured steady and accurate fire at a high rate. (Author's collection)

equipment was clumsy and fragile. In practice, as much as half of a field gun's potential range of up to 6,000m might be wasted through the inability of battery commanders to see long-range targets through their binoculars, or of remote observers to pass accurate and timely information for the adjustment of fire and shrapnel time-fuzing. Long-range indirect fire also demanded the exact placing of guns and targets on accurate maps, which was not achievable in manoeuvre warfare. For these reasons, range was less important in contemporary field artillery design than mobility and rate of fire.

Quick-firing field guns

Prior to 1900, field guns were loaded with a separate shell, bagged propellant charge, and primer; they also lacked any system on the carriage to reduce the effect of recoil. However, contemporary 'quick-firing' (QF) guns were used in fixed mountings on warships, for engaging fast targets such as torpedo-boats. Their much faster rate of fire was due to quick-acting breech mechanisms; the use of 'fixed' ammunition (shell, propellant and primer combined into one, like a giant rifle round); 'buffers' to absorb recoil, and a 'recuperator' to return the barrel to 'battery' (firing position).

The French won the race to develop a true QF field gun: the *Matériel de 75mm Mle 1897*. This *'Soixante-quinze'* or 'French 75', unveiled for the 1900



The 'French 75' was far more complex than any of the 'BL' artillery it replaced, and operating and maintaining such sophisticated equipment was a real challenge for field artillerymen. (Author's collection)

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army manoeuvres, was a technological masterpiece that combined a fast-acting Nordenfeldt rotary breech, fixed smokeless-powder ammunition, and a long barrel-recoil system that left the carriage almost immobile when the gun fired. By 1910 every major army had developed or purchased QF guns, and French doctrine in their use was closely studied.

The French reduced the traditional 6-gun battery to 4x '75s', which could deliver the same weight of fire in a given time. The maximum range of the HE shell was about 6,500m. The practical range for the 'Robin' time-fuzed shrapnel shell was less than half that, but, bursting 5m above the ground, its balls could sweep a zone 25m wide by 200m deep – enough to cause 50 per cent casualties to an exposed infantry company in close order. In test conditions the rate of fire was 30 rounds per minute, but neither gun nor crew could sustain that for long. For operations, targets would typically be engaged with a *rafale* ('squall') of 5 or 6 rounds per gun, fired independently as fast as possible, followed by a lull; another *rafale*; another lull (of variable, random length); and so on. Alternatively employed against dispersed, ill-defined or moving targets, *tir progressif* or 'searching fire' was a total of 8 rounds per gun fired in twos, with a 'lift' of 100m range between each pair of rounds. The whole fire mission was fired as quickly as possible, with no orders beyond the initial 'Fire!', thus 'searching' an area 100m wide (the length of the battery line) by 400m deep with 32 shells.

Ammunition consumption

The implications of the new QF guns for battlefield logistics seem to have been largely ignored, and experience in 1914–15 would prove that estimates for ammunition consumption were woefully inadequate. In 1913, British war plans allowed 1,000 rounds for each of the Royal Field Artillery's QF 18-pdrs in theatre, plus 300 in stores in the UK, plus another 500 rounds delivered from ordnance factories *within six months*. At battery level, there were just 176 rounds per gun – enough for 44 minutes' firing at 'Rate 4' (4rpm). At that rate the British Expeditionary Force's entire stock of 18-pdr ammunition amounted to less than 5 hours of rapid fire, with a further 75 minutes'-worth in store in the UK. In fact, an 18-pdr gun in 1918 might be expected to fire 600 rounds *per day*.

Field howitzers

The adoption of rifled field guns and shrapnel shells had ended the field battery's historic mix of higher-velocity, flat-trajectory guns firing roundshot and canister, with a couple of relatively lower-velocity howitzers firing explosive shells at a high angle to plunge down behind enemy works. However, a revival of interest saw the *15cm schwere Feldhaubitze* ('5.9in heavy field howitzer') enter German Army service in 1893, followed in 1899 by a 10.5cm (roughly 4in) howitzer for field batteries. The 15cm piece fired a 41kg (90lb) shell just over 6,000m, but weighed only 2,189kg in action – light enough for a six-horse team. Its adoption was to give the Germans a serious and enduring advantage during World War I.

After some hesitation, the British Army introduced a 5in field howitzer firing 50lb HE shells to complement the RFA's field guns, and this proved its value in the Boer War (1899–1902). Nevertheless, prior to 1914 howitzers were typically outnumbered 3-to-1 by guns in both German and British field artillery, while the French, convinced of the superiority of their '75', failed to adopt a howitzer for field batteries.

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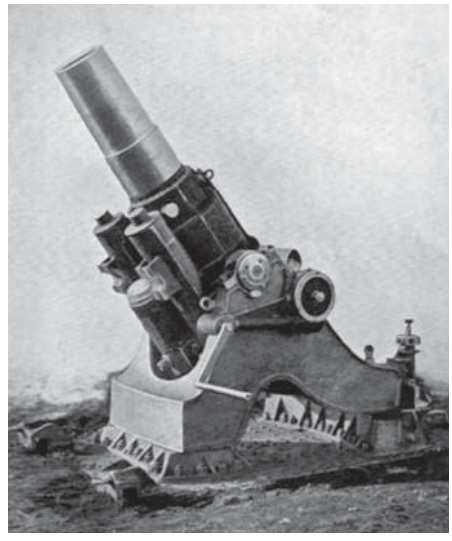
Siege artillery

Germany faced the certainty of confronting well-designed modern fortifications in any future European war, and studied the lessons of the 1904 Japanese siege of Port Arthur during the Russo-Japanese War. These included the value of both very heavy and very light siege weapons. After developing a static 39.5cm howitzer, Krupp produced a mobile 42cm weapon, of which the first example was delivered in 1913. Weighing 43 tonnes, and broken down into five loads for transport by rail or specially designed Krupp-Daimler tractors, they fired an 830kg (1,830lb) shell 12.5km (7.75 miles). For secrecy this super-howitzer was designated *42cm M-Gerät 14 Kurze Marine Kanone* ('M1914 short naval gun'), but it would become famous as '*Dicke Bertha*' or 'Big Bertha'. At the opposite end of the spectrum, the Japanese use of improvised light mortars led to the German adoption of small but rather sophisticated muzzle-loading indirect-fire *Minenwerfer* ('mine-throwers'), operated not by the artillery but by the *Pioniere* (assault engineers).



The Austro-Hungarian Skoda 24cm (9.4in) M1898 howitzer represented the ultimate in siege ordnance at the dawn of the 20th century, and even the British Army purchased four examples for the Royal Garrison Artillery. By 1914 the British would just be receiving the first of their own advanced 9.2in siege howitzers; but by that date Germany had secretly produced 'Big Bertha', with a calibre of 42cm (16.5in). (Author's collection)

British experience in the Boer War led to the development of an advanced 9.2in siege howitzer; a single trials example was delivered in 1913, and the type was just entering service on the eve of the Great War.

Heavy field artillery

At the turn of the century there was increasing interest in 'heavy field' artillery – more mobile than siege artillery, but more powerful than field artillery (e.g. the German 15cm heavy howitzer of 1893). Experience in South Africa led the British Army at home to mount Royal Garrison Artillery (RGA) 4.7in and 6in guns on 'travelling' carriages as an interim measure while a purpose-built 60-pdr (5in-calibre) gun was developed. The 4.7in, 60-pdr and 6in guns would all see extensive Great War service, but by 1914 British preparations were little further advanced than the proof-of-concept stage.

France neglected heavy field artillery until very shortly before the outbreak of war, when a 107mm design by Shneider and Putilov for the Russian Army was modified and adopted as the *Canon de 105 Mle 1913*. This made little immediate difference, but had longer-term significance: the 105mm shell proved much superior to the 75mm under trench-warfare conditions, and this would become a standard field artillery calibre.

DOCTRINE ON THE EVE OF WAR

French theorists decided that modern tactics of dispersal and use of cover would make it difficult for scouts to locate the enemy's main force, since the two sides' reconnaissance forces would effectively screen each other. Accordingly, the French embraced the concept of 'encounter' battles, resulting from two advancing armies colliding. Victory would go to the one that reacted fastest and most aggressively, bringing down a storm of fire on the enemy and then fighting through while he was still disorganized. The doctrine envisaged in the French Field Service Regulations from 1883 onwards was based on the use of an advanced guard strong enough to defeat the enemy's screening force and cause him to deploy his main body, thus revealing its location and strength.

At divisional level, the advanced guard would consist of a quarter of the divisional infantry (three battalions) plus a quarter of the artillery (three

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A battery of 'French 75s' deployed in open country. This photo was in fact taken after the resumption of manoeuvre warfare on the Western Front, near Longpoint on the Aisne in July 1918. (IWM Q47947)

batteries of '75s'), marching ahead of the main divisional columns. In theory a battle would unfold in three phases: first, the advanced guard would 'fix' the enemy and force him to deploy; then the main body of the division would enter the fight to wear him down – the *combat d'usure*; and finally, he would be overrun or outflanked using divisional and corps reserves. The concept was based on relentless attack – *'offensive à l'outrance'* (scarcely any thought was given to defence) – and a set-piece battle, into which an increasing number of troops would be fed until a tipping-point was reached and the enemy's resistance was overcome. French QF battlefield artillery was supposed to provide a storm of direct-fire support for the decisive action, which would be the infantry attack. French doctrine asserted that shock was always preferable to fire, and that the French Army would win because of its infantry's fighting spirit.

Both the German and French doctrines stressed co-operation and liaison between the combat arms. As propounded by Gen Percin, the French Inspector General of Artillery, the vital unity of command should be achieved by forming artillery and infantry components engaged on the same task into a combat group under the authority of the infantry commander; this was known as *liaison par le haut*. The artillery of the resultant combat group was divided into 'counter-batteries' and 'infantry batteries', the former to engage the enemy artillery and the latter to provide intimate support to the infantry units. The commanders of the infantry batteries and the supported infantry units were required to establish *liaison par le bas*. Once the task was completed, the artillery units reverted to the authority of the senior artillery commander and returned to the artillery reserve to await the next task. To modern eyes this inter-arm co-operation and liaison, with adjustable command relationships, seems sensible, but in an era of prickly careerists subordination of the artillery to the infantry was not always accomplished smoothly.

French doctrine was set out in the *Réglement* of 1910, and tested in the Picardy manoeuvres of that autumn. Two army corps took part, each of five

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brigades and a cavalry division. The army corps had a new 30-battery artillery establishment, and eight reconnaissance aircraft also participated. The subsequent post-exercise report was a catalogue of mistakes, but this should not detract from the effort the French were making to develop and test cutting-edge doctrine. Some of the issues exposed were inevitable problems of waging war in a world where firepower had increased exponentially in range, accuracy and lethality, but battlefield communications had not improved since Julius Caesar invaded Gaul. While at the strategic level steam trains and ships had revolutionized the movements of large numbers of troops, and the telegraph and telephone had transformed static communications, it remained a fact that on the battlefield soldiers could still only manoeuvre at the speed they could march, run or ride, and orders and messages were carried at the same speed.

Headline mistakes in 1910 included 'blue-on-blue' incidents when artillery batteries engaged their own side, and an episode when a battery mistook sheaves of corn for advancing enemy troops. 'Fratricide' is an obvious possibility in an exercise where both sides are wearing the same uniform; but target identification with binoculars at the ranges the '75' could reach was nearly impossible. The Germans made extensive use of observation wagons fitted with extending ladders; importantly, they also routinely planted observation posts (OPs) overlooking the ground over which the army was manoeuvring, well forward and linked to the batteries by telephone. All the major armies were also investigating the potential of tethered observation balloons and reconnaissance aircraft. The former, though vulnerable to fire, had the advantage that a telephone cable could be run down the tether, enabling instant two-way communication. Aircraft could venture over enemy territory, but communication was generally limited to the pilot dropping written messages and responding to signal panels laid out on the ground.

Apart from observation, the most significant problems exposed in the French exercises were overall slowness and difficulties in command and control. The deployment of artillery seemed ponderous, and as new batteries joined the battle they created a patchwork of overlapping and frequently conflicting command relationships.

The warming of relations between Britain and France after 1904 allowed British officers to attend French exercises and see the '75' at work.

French soldiers practise laying out signal panels for aircraft, the large letters forming simple coded messages that could be read from the air. This method had to be used throughout the war; the photo was taken at Soupire on the Aisne front in May 1917. (IWM Q70882)

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Initially there was enthusiasm for the French vision, which led to closer inter-arms co-operation and training in the British Army. It was noted, however, that French doctrine ignored some lessons from the Boer and Russo-Japanese wars, and the British hedged their bets: they retained the 6-gun artillery battery, and continued to plan for a proportion of field howitzers and heavy field artillery to bolster their QF 18-pdr field and 13-pdr cavalry batteries.

It is often stated that the German Army of 1914 was 'more professional' or 'better trained' than its opponents, but this simply was not true. In first-line units equipment and training were extremely good, but the mobilized army also included a large proportion of reservists with varying standards of training, and 'legacy' equipment including older BL artillery. Like the French, the German Army trained for an aggressive, attacking style of warfare. However, they placed much less reliance on 'fixing' the enemy in order to fight a set-piece battle; instead, German doctrine concentrated on deep penetration and flanking manoeuvres to dislocate enemy forces and shatter their cohesion. In simple terms, the difference between the German and French armies was that the Germans had better tactical doctrine, and a broader, more versatile and effective selection of artillery. The British had a similar 'manoeuvrist' approach based on Boer War experience, and a similarly versatile selection of artillery – but in such tiny numbers when compared with the vast conscript armies of the continental powers that the British Expeditionary Force (BEF) of 1914 would scarcely seem like a serious contribution to a European war.

Equipment

The mutual study of technology, doctrine and tactics between France, Germany, Great Britain and Russia had left each of them with a similar primary field artillery piece: a high-velocity, quick-firing gun of around 76mm (3in) calibre. The British also had a 4.5in (114mm) field howitzer, but lacked a heavy field howitzer. The French lacked a field howitzer, but had a few quite advanced heavy field howitzers. Germany had well-designed and well-integrated howitzers in both the field (10.5cm) and heavy field (15cm) classes.

The pace of development increased as a European war became a probability, with the Germans methodically updating the performance of what appeared

A

GERMAN HOWITZER BATTERY ADJUSTING FIRE, AUGUST 1914

To bring effective fire to bear meant ensuring that the mean point of impact – the centre of the zone where the shells were striking – was 'on for line' and 'on for range', and this was achieved by using the bracketing system developed by German artillery in the late 19th century. This schematic represents the most basic practice as used at the beginning of the war. A battery of *10.5cm leFH 98/09* light field howitzers, neatly lined up in pre-war style, are engaging a patrol from the advanced guard of a French formation at a range of 2,000–3,000 metres. The battery is commanded by a captain *(Batterie-Führer)* and divided into two *Züge* (sections) under subalterns. In this scenario 'line' is not an issue, since the target is visible.

(1) Using high-powered 'scissors' binoculars, the battery commander on the observation wagon to the left of the gun line makes a first rough estimate of range, and orders a first shot from a single howitzer with the range dial set to that estimate. This falls well beyond the target.

(1a) Observation wagon *(Beobachtungswagen)*; this has an armoured shield complete with a footplate, mounted on an extending ladder (not deployed here). Canted forward, the ladder could raise the observing officer and his shield to more than twice the height illustrated here.

(2) Apart from changing the elevation angle of the barrel, range could be increased or decreased by varying the propellant charge in the shell; in 1914 the *leFH 98/09* had seven charge increments. The officer has shortened the range by 100m, but the second shot still falls beyond the target.

(3) The range is again shortened by 100m, and this shell drops short. The officer now knows that the correct range is within a 100m bracket formed by his last two shots.

(4) The commander 'splits the bracket' by adding 50m to the last range order, and orders all 6 pieces to fire one shot at that setting. The fall of the shells shows the mean point of impact to be slightly in front of the target, so he could add another 25m to the range; but HE howitzer shells are an 'area' weapon, and the French patrol has been destroyed.

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The British BL 8in siege howitzer was converted from obsolete 6in guns to meet a long-standing requirement for a heavy howitzer. This is one of the first examples in action, with 19th Siege Battery, RGA at Gorre in June 1915. (RAHT AL 1148.5)

to be the right mix of equipments and calibres. The French 1904 *Canon court de 155 Mle 1904TR* was a 155mm howitzer with a revolutionary semi-automatic breech mechanism and a 4rpm rate of fire, but was only acquired for the heavy artillery branch in small numbers. On the eve of war the French finally updated their existing elderly heavy artillery: the 155mm M1881 howitzer was modified in 1912, and the 155mm de Bange M1877 heavy gun in 1914. A new 105mm heavy gun, a 280mm 'mortar' (siege piece) from Schneider, and the Filloux 370mm mortar were adopted; these were too few and too late, and lacked any real tactical doctrine for their use, but would become important during the static trench warfare on the Western Front.

Doctrinally, the most difficult issues to resolve were what we would now term 'C3' (command, control and communication); plus the one factor always overlooked in peacetime – logistics.

1914: MANOEUVRE WARFARE ON THE WESTERN FRONT

The soldiers who marched to war in August 1914 were trained and equipped for a fast-moving war of manoeuvre. Given the size of the armies, the scale of the operations, the numbers of freshly mobilized reservists, the paucity of good maps and the absence of reliable mobile communications, the potential for confusion was almost limitless. Under the circumstances it is unsurprising that many commanders defaulted to the tried-and-tested over the new-and-unproven, and actions in the opening phase of the war seemed to owe more to the 19th century than the 20th. For example, the famous British action at Néry on 1 September 1914 saw a few beleaguered QF 13-pdrs of L Battery, Royal Horse Artillery (RHA) engaging German 7.7cm guns at a range of 720 yards, holding the line until the Germans were driven off and cavalry reinforcements arrived.

* * *

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German Artillery, August 1914

In 1914 the German artillery consisted of 'field' and 'foot' components. There were 102 field artillery *(Feldartillerie)* regiments, and 29 reserve field regiments. Each field regiment comprised two battalions *(Abteilungen)* each of three batteries. One *Feldartillerie Brigade* (comprising two regiments, of which one of the four *Abteilungen* had field howitzers) was attached to each of the Army's 51 infantry divisions. On mobilization a further 32 reserve divisions were formed, but each with a divisional artillery of nine batteries instead of 12. One horse artillery *Abteilung* (three 4-gun batteries) was attached to each of the army's 11 cavalry divisions.

The German foot artillery *(Fußartillerie)* was broken up on mobilization to be distributed at army and army group level. There were 26 foot regiments *(Bataillone)*, comprising some 400 foot batteries; each foot battery also formed a reserve foot battery on mobilization. Regiments equipped with the 15cm heavy field howitzer had eight 2-piece batteries (16 howitzers).

Germany declared war on Russia on 1 August 1914 and on France on 3 August, invading neutral Luxemburg and Belgium in order to envelop the French Army from the north. Following the violation of Belgian neutrality, Britain declared war on Germany on 4 August.

The Germans anticipated that the Belgians would be brushed aside in a couple of days, but determined resistance in fact held up the German advance for ten days. Twelve forts surrounding the city of Liége controlled the vital crossings of the River Meuse; about 25 years old, they consisted of underground positions thickly protected with concrete and topped with steel cupolas, bristling with guns. Infiltrating between them, the Germans forced the surrender of the city itself, but the forts held out, threatening German lines of communication. To reduce them the Germans brought up siege artillery including 21cm 'mortars' and the 42cm 'Big Berthas'. The bombardment started at Fort de Pontisse on

German field artillery on the march during the advance into France, September 1914. Each of the two *Abteilungen* of a *Feldartillerie Regiment* had three batteries of either 6x 7.7cm guns or 4x 10.5cm howitzers; one of the four *Abteilungen* of each two-regiment *Feldartillerie Brigade* had howitzers, and the other three *Abteilungen* field guns. (IWM Q56553)

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French Artillery, August 1914

Once mobilized, the French artillery consisted of 65 divisional regiments (equipped with '75s'); 20 army corps regiments ('75s'); two mountain regiments; ten cavalry division/horse artillery regiments (light 75mm guns); five heavy artillery regiments; nine foot artillery regiments; and three colonial artillery regiments ('75s') – the great preponderance of 75mm field guns is obvious.

12 August, and 42cm shells spectacularly detonated the magazine at Fort de Loncin on 15 August, killing most of the garrison; the last two forts surrendered the following day. (Although this was a stunning demonstration of the advances in the power and mobility of artillery since 1900, in the aftermath of Liége the effectiveness of German siege artillery was in fact overestimated; the Belgian forts had been more vulnerable than they appeared.)

The Battle of the Frontiers: Virton-Ethe

The French moved to meet Germany's modified 'Schlieffen Plan' with their own 'Plan XVII', which involved an attack into Alsace-Lorraine and a strong move to head off a German attack through the Ardennes; however, the French advance met with almost universal disaster.

What happened when French tactical doctrine confronted reality is usefully illustrated by the battle of Virton-Ethe, which took place on 22 August 1914 as Gen Boëlle's IV Corps was advancing north into the Ardennes to strike the left flank of German forces swinging through Belgium. Boëlle's corps consisted of the 7th and 8th Divisions, each comprising two brigades; each brigade had two regiments of infantry (so six battalions), a company of engineers, a squadron of cavalry, and two or three 4-gun batteries from the 36-gun divisional artillery regiment. Corps troops consisted of a reserve infantry brigade, a company of engineers, four squadrons of cavalry, and the 48-gun corps artillery regiment.

On the morning of 22 August the two divisional columns were moving through hilly, heavily wooded country with few good roads. On the right, Gen de Trentinian's 7th Div was advancing with four squadrons of corps cavalry and an infantry battalion screening an advanced guard of one infantry regiment, 12 guns from the divisional artillery, and the divisional engineers. The main body, an hour and a half behind, comprised the remainder of the divisional infantry and guns, and the corps artillery and engineers.

Moving north in difficult terrain shrouded by fog, the corps cavalry (who had left their supporting infantry battalion behind) stumbled into elements of the German 10th Inf Div advancing south on the same axis. Initially the German reconnaissance screen and skirmishers were brushed off, and the French cavalry continued to advance – until they were first pinned down by fire, and then virtually annihilated while attempting a charge in open order (which was the recommended action for determining the strength of the enemy).

The divisional advanced guard arrived and deployed north and north-west of the village of Ethe; but most of its artillery was destroyed by fire from German 7.7cm guns and 10.5cm howitzers before it could deploy, and what remained was forced to take cover in dead ground. A battalion placed as flank defence for the divisional column of march was overwhelmed by five times its number of Germans emerging suddenly from the fog. General de Trentinian was, as per doctrine, forward with his advanced guard, and

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therefore had an excellent perspective on the situation – but absolutely no way to influence it, since despite sending several messages back he could not get the main body of his division to come up and reinforce the advanced guard.

The reason was that the main body was halted at a wood line some distance behind, unable to advance because of German artillery fire, which also prevented the remainder of the French guns from deploying – and even if they had, they could not identify the German battery positions. The situation resembled pre-war French exercises in that two forces were colliding, and the advanced guard had certainly located the enemy; but rather than 'fixing' them while the main body manoeuvred to attack, the advanced guard had got itself pinned down, while the main body was itself 'fixed' by German artillery fire.

At about noon Gen de Trentinian ran the gauntlet of German shellfire to reach the main body of his division, only to discover that in his absence this had been ordered by the corps staff to abandon the advanced guard to its fate and retreat. Rounding up some infantry, Trentinian ordered them into the attack, supported by two groups of divisional artillery which had been standing by helplessly for lack of locatable targets. Unfortunately, German forces had infiltrated between the 7th and 8th Divs, and Trentinian's attack soon turned into a defence. Meanwhile, the remains of the advanced guard engaged in desperate street-fighting in Ethe, the survivors only escaping after nightfall. The 7th Div lost an estimated 5,300 casualties – one-third of its strength.

To the west, the 8th Div had been struggling to advance towards Virton, likewise in difficult terrain masked by fog. Three battalions of the advanced guard were engaged as they crested a hill; joined by the rest of their brigade, they tried to attack, but failed for lack of effective artillery support. The division withdrew south, rallied, managed to bring its artillery into action, and mounted an effective counter-attack. However, the division's advance had been halted, and its advanced guard had been mauled in the day's fighting.

In the wooded hills of the Ardennes the German howitzers had a distinct advantage over the flat-trajectory French '75s', but the Germans also made good use of their field guns. The main French problems were organizational. Too high a proportion of the corps' artillery was under corps command, and too much of the divisional artillery was held back in the main body of the advancing divisions. French batteries were kept limbered up and ready to move while commanders struggled to interpret the developing battle, unwilling to commit the artillery too early, but in serious danger of committing it too late. The IV Corps artillery regiment, the 44th, had started out with the 7th Div main body; struggled to identify targets to engage; then was ordered to move to support the 8th Div, where some of its batteries engaged effectively; but others never made it, and became caught up in a general retreat south – despite the fact that elements of both 7th and 8th Divs were still fighting for their lives.

When in contact, the German reconnaissance troops and skirmishers took a defensive stance, while their main body spread out in order to find and turn the opponent's flank. The French, by contrast, kept trying to break through at the point of first contact, with a piecemeal approach that never gained enough mass. The French artillery struggled against organizational handicaps, and the limitations of flat-trajectory guns among wooded hills. Following the Battle of the Frontiers tactics were quickly revised, with the instruction that artillery should be massed to prepare to support the infantry assault; however, the basic, flawed premise of deploying an advanced guard in a 'fighting reconnaissance' role remained.

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At the outbreak of war Britain had just one example of the BL 9.2in siege howitzer in service – the prototype nicknamed 'Mother'. Here 'Mother' is seen in action with 10th Siege Battery, RGA near Neuve Chapelle in November 1914. (RAHT AL 190.3.30)

Mons

By 21 August the BEF was advancing to extend the French Fifth Army's left flank when the French plan began to disintegrate. The two corps of the BEF were facing two German armies, and as the French were driven back they were in danger of being enveloped on both flanks. The risks involved in fielding a small, well-trained and well-equipped army, and hoping it would ride to victory on the coat-tails of a much larger ally, quickly became apparent as the French fell back under intense pressure. By 23 August the BEF was strung out beyond Mons with the artillery positioned behind the infantry, ranging from just a few hundred yards behind to over 6,000 yards. The BEF had brought 396 pieces of field artillery and 24 heavy guns – small change compared to the French and German parks. The British cavalry screen out forward prevented the gunners from firing to register potential targets, and the nature of the ground made it difficult to judge distance and spot the fall of shot. ('Registering' meant obtaining by fire the range from the gun line to significant visible features in the landscape.)

Insufficient thought was given to positioning the artillery to provide offensive support by hitting the enemy in depth, with the result that the British infantry were exposed to enemy artillery fire without their own guns being able to reply effectively. By the end of a day of chaotic fighting the British infantry had beaten back the German attack, and held the Allied left flank, but with little help from the artillery. Fewer than half the guns had played any part, and of those that did many ended up in the infantry firing line, fighting desperate actions over open sights.

Although there was some preparation of gun pits, the general tendency to adopt open or semi-covered positions led to British guns being exposed to effective counter-battery fire – for example, 70th Battery, RFA, which was firing on enemy infantry at a range of 2,300 yards, and enemy guns at 3,300 yards, was itself fired upon by German howitzers, and lost three guns put out of action by splinter damage to the vulnerable recoil-spring housing above the 18-pdr's barrel. The British heavy guns did attempt counter-battery fire, but were handicapped by the inability to clearly identify targets on ground that lacked good vantage points for OPs. By midnight the British were aware that the French on their right flank were retiring; a counter-attack planned for the morning of 24 August was now out of the question, and the 'Great Retreat' began.

The retreat from Mons

The German Army's infantry varied greatly in tactical readiness. Troops instructed in the latest thinking employed 'Boer'-style small-unit techniques with NCO-led open formations, while some reserve regiments still advanced in 1870s-style close ranks with NCOs to the rear to maintain the line. These were not the only units that proved ill-adapted to modern battlefield realities, and one such was encountered by a British howitzer brigade near Selvigny. Amazed, the British gunners watched a German officer galloping along a ridge beyond

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the Warnelle ravine, at about 4,000 yards range, followed by a mounted orderly carrying a chequered flag. Soon afterwards horses and guns came into view over the ridge – a battery coming into action. The British howitzers immediately opened fire, destroying the German guns before they could fire a round.

A serious shock for the Allies was the widespread German use of 15cm heavy field howitzers – a calibre of '5.9 inches' to the British (who considered their own 6in/152mm howitzer a siege weapon). The range and hitting-power of the '5.9', demonstrated against bunched British transport at Le Cateau, gave it an ascendancy it never really lost. However, the German 7.7cm field gun was emerging as rather less of a success compared to the British 18-pdr, which, although limited in range and rate of fire, had the most effective shrapnel shell in its class. Heavier, it also burst lower than the German round, with deadly effect against the massed formations used by some German infantry. However, the lethality of QF shrapnel was compromised by the emerging problem of ammunition supply. The idea that QF field guns in desperate rearguard actions would use the same amount of ammunition as BL field guns of the 19th century was hopelessly naïve. As one British gunner commented after the war, 'You cannot *devastate* if you are counting shell all the time'.

Both the British and French had difficulty bringing their artillery to bear when and where it was needed. During 'the Retreat' the British artillery's performance was more creditable than it had been at Mons, but British guns were deployed alongside the infantry in view of the enemy. Affording the infantry the closest possible support resulted in artillery being caught up in the fighting at almost Napoleonic ranges, at a heavy cost in batteries overrun and guns lost – largely due to the vulnerability of horse-teams on a battlefield swept by shrapnel and small-arms fire. At Le Cateau the Germans captured 37 British guns; thereafter the lesson was learned, and if British guns were again caught up in front-line fighting it was by accident rather than design.

Le Cateau was a tactical victory for the Germans, but a strategic one for the Allies, as the British managed to fight off envelopment and withdraw to fight another day. General von Kluck, believing that he had driven the BEF from the field, disregarded the Schlieffen Plan's goal of a westward hook behind Paris to encircle the French capital. Instead his First Army cut quickly

Though photographed later in the war, this is a graphic illustration of the effect of shellfire on a horse-drawn battery. These RFA 18-pdr guns and their limbers have been abandoned by the side of a timbered 'corduroy' road, with at least three dead horses. If just a single animal from a harnessed six-horse team was killed or maimed by enemy fire it reduced the whole team to chaos until the casualty could be unbuckled and 'cut out', preventing the movement of the gun for a significant time. (IWM Q42265)

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down to the east of Paris, to roll up what he believed was the exposed French flank. But despite defeats and losses neither the French nor British armies were losing their cohesion, and after costly and confused fighting the German advance was finally halted on the Marne (5–10 September).

The Germans disengaged, and from mid-September both sides tried to outflank each other to the north – the 'Race to the Sea'. The First Battle of the Aisne (15–18 September), an Allied attempt to outflank the Germans that was halted by field fortifications, really marked the end of the opening, mobile phase on the Western Front. (It also saw the first British aerial observation of artillery fire; and the beginnings of what became 'the Shell Crisis', as artillery ammunition ran dangerously low.) The First Battle of Ypres in October–November prevented the Germans from seizing the Channel ports, but resulted in the virtual destruction of the BEF.

* * *

The battles between August and December 1914 cost each side almost a million casualties. The Germans had won the tactical battles, and now occupied most of Belgium and a significant portion of eastern France; their prize was the luxury of digging in on ground that would everywhere give them an advantage against subsequent Allied attacks.

The chaotic encounter battles of 1914 had seen artillery misused (by placing it too far forward), or underused (by holding it back in reserve too long), but some lessons were already emerging. Henceforth some of the long-range potential of modern field guns would be exploited by moving them back from the front line; this ensured that they would not be overrun by any sudden attack, and allowed them to be massed. The grouping of artillery was impractical in manoeuvre warfare; to have any chance of influencing a battle of manoeuvre field artillery had to be dispersed into independent battery or even section commands under operational control of the infantry. In a British division a brigadier-general styled the Commander Royal Artillery (CRA) was

B

BRITISH 'CREEPING' & 'PILED UP' BARRAGES; THE SOMME, 1916

To support infantry attacks massed 18-pdrs fired linear fire missions in a series of **'lifts', shown here as red lines**. The standard became a 100-yard lift every 3 minutes, at a rate of fire of 3rpm per gun. The barrage of airburst shrapnel shells started in No Man's Land, advancing through and beyond the objective. The effect was a wall of fire advancing in front of the attacking infantry, and because shrapnel shells sprayed balls forwards the infantry could follow close behind the barrage. The fire would pass across the enemy front-line trench and continue into the support and reserve lines to prevent a counter-attack. It was vital to keep the barrage and the infantry as close together as possible, which required training, co-ordination and trust. In bad ground conditions, such as those encountered in autumn 1916, the interval between 100-yard lifts could be as long as 5 minutes to enable the struggling infantry to keep up. These simplified illustrations show variations on the creeping barrage, but real fire plans were obviously much more complex and varied.

(1) 'Creeping' barrage This was very effective, since shells from guns positioned at 25-yard intervals swept almost every inch of the target zone with shrapnel, and were particularly effective against machine-gunners hiding in shell holes. However, there were disadvantages. Here, the forward-bulging 'salient' of the German front-line trench **(A – A)** has been suppressed, but the next lift has missed the fore-and-aft flanking sections behind and on either side of it. When the shellfire moves on, 'getting away' from the infantry, German machine-gun crews **(1a)** have time to emerge from their deep dugout shelters **(1b)** through entrances in the unsuppressed sections, and bring the attackers under enfilade fire from the flanks **(MG, MG).**

(2) 'Piled up' barrage This tactic proved effective in trapping defenders below ground until it was too late. The gunfire advances in the same 100-yard lifts, but once the guns firing on the forward 'bulge' reach their target they stop 'creeping' and continue firing on it while the attacking infantry lie down. The guns either side continue to 'creep' on to the 'refused' trench-lines flanking the bulge on each side, where the infantry also pause. When all the guns have been firing simultaneously on all sections of the front-line trench, they will all lift together to the rear of the trench, and all the infantry will assault together before the Germans can bring up their MGs.

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1a

1

MG

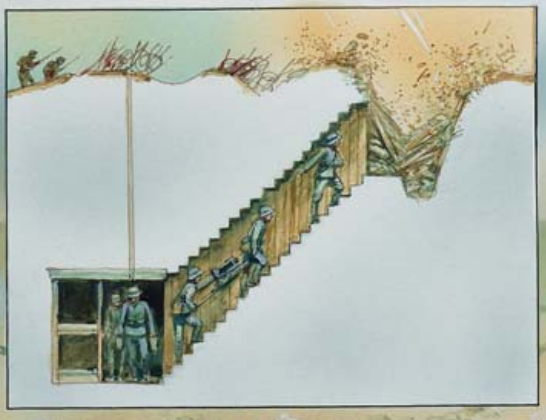
A

MG

A

2

1b



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British 26cwt 6in siege howitzer of 6th Siege Battery, RGA in action on the Western Front, winter 1914–15. It sits on a wooden gun platform, and even this early in the war it has rudimentary overhead camouflage made from cut saplings. (RAHT AL 190.3 series)

an 'advisor' to the divisional commander, with virtually no supporting staff, personal authority that extended only to a few howitzers and heavy guns, and no practical way of communicating with dispersed field batteries. The increasingly static warfare from late 1914 made it possible to group artillery under direct command of a senior artillery officer, which was to have a dramatic effect on the development of artillery science.

The end of 1914 saw the first tentative use of 'offensive support', including counter-battery fire and harassing fire in depth. British infantry were already relying on 'SOS' fire, with guns registered to protect friendly troops with a curtain of fire when not engaged on other fire missions. The German use of HE rounds for field guns was imitated by the British, who belatedly introduced an HE round for the 18-pdr (shrapnel, so effective in the open, was of little use when engaging troops under cover). The French already had an HE shell for the '75', which proved to have a particularly lethal blast effect; before the war HE had been considered an anti-materiel rather than a personnel-killing munition.

It was already possible to see the beginnings of a transformation in the artillery's role – from softening-up the enemy for the benefit of the infantry, to the actual replacement of infantry firepower as the dominant force on the battlefield.

1915: STALEMATE, INVENTION & EXPANSION

Positional warfare

Strategically, 1915 saw the Germans occupying defensive positions while the Allies attempted to puncture the German front with offensives in Artois and Champagne. The BEF was being expanded with a flood of reinforcements, while the Germans had to reorganize to make the most of the troops and reservists they had available (during 1915, German field-gun batteries were reduced from 6 to 4 guns to enable the creation of new batteries). On both sides, the shortage of ammunition and equipment was crippling. National economies and industrial production needed fundamental reorganization for what was now clearly going to be a long war, which would consume complex manufactured items in unimagined quantities.

Tactically, by the end of 1914 it was clear that the magazine rifle, the machine gun and QF artillery had made the battlefield lethal to an unprecedented degree. The only way to survive the storm of lead was to dig in, and as the advantage shifted from attack to defence the opposing armies were soon mired in stalemate. The balance of importance shifted from the *élan* of the infantry to the skills of the military engineer, who was responsible

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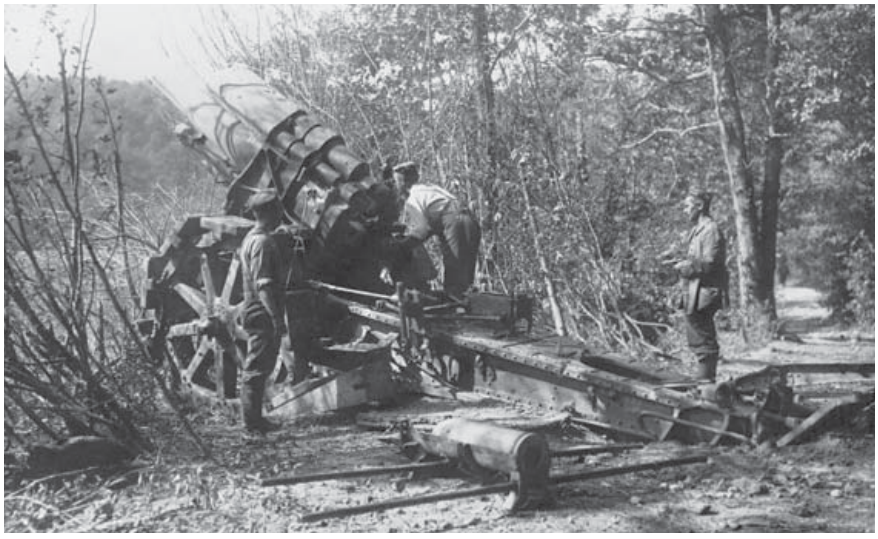

A German *21cm Mörser 10* (M1910 siege howitzer) on the Argonne front, August 1915; a shell lies on its carrying cradle in the foreground. Each foot artillery *Bataillon* had just two of these very heavy pieces. (IWM Q42436)

for building and defeating fortifications and fieldworks, and ensuring communications. When defending or attacking fortifications it was often difficult to use direct-fire weapons like rifles; instead it was useful to have short-range area weapons such as explosive grenades. Hand grenades, and short-range bomb-throwers such as the German *Minenwerfer*, formed part of the equipment of the engineers and pioneers, but at first they were available only in the relatively small quantities that had been anticipated as being sufficient for the occasional set-piece siege.

Return of the mortar

Hand grenades or 'bombs' were useful in the assault and defence, and rifle-grenades could sometimes be projected as far as from one trench-line to the other; but there was a need for a more powerful weapon, capable of indirect fire and light enough to be manhandled forward to give intimate support to an assaulting force.

In siegecraft the historic solution had been the 17th-century Coehorn mortar, a stubby barrel fixed at an angle to a substantial wooden base, and firing a spherical iron shell with a gunpowder filling. Its descendants had finally fallen out of use after the American Civil War; but in 1915 the French Army found some in the dusty recesses of its stores and was able to supply these antiques to the BEF (who called them 'Toby mortars'). During the siege of Port Arthur, British observers had taken note of improvised Japanese 'trench mortars'. In 1915, when the need for 'trench howitzers' became urgent, the Royal Engineers set about designing and manufacturing light mortars that could be rapidly supplied to the infantry. During that year eight patterns of trench mortar would enter British service on the Western Front, in addition to cruder bomb-throwers powered by springs or rubber bands.

Unlike the sophisticated *Minenwerfer* in German service, the 'Indian Pattern Trench Howitzer' designed by the 3rd (Bombay) Sappers & Miners consisted simply of a

The 3in Stokes mortar was accepted in spring 1915, and was first used in action at Loos that September. At 108lb (49kg) it was far lighter than the German medium-calibre *Minenwerfer*; and it broke down into three carrying loads, the heaviest being the 43lb (19.5kg) barrel. It was therefore practical for both trench warfare and for being carried forward with the advance, and fired a 10lb 11oz (4.8kg) bomb out to 750–800 yards' range. Note the sturdy construction of the bipod: the propellant charge delivered a considerable shock to the lightweight mortar tube. For static warfare it was usually emplaced in sandbagged pits either behind the front-line trenches, or pushed out forward at the end of saps, depending on the width of No Man's Land. This crew, photographed near Neuve Chapelle in June 1917, are from the Portuguese Expeditionary Corps (IWM Q6440)

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Unmatched for lightness and mobility, the Stokes mortar was even supplied to Sharif Hussayn's Arab Northern Army during the British-supported revolt against the Turks; here LtCol T.E. Lawrence (right) holds a bomb during a demonstration of its use. The tube on the front cap held a No. 145 percussion grenade fuze, and the perforated tube on the rear cap the basic propellant cartridge. Up to four ring-shaped incremental charges could be added to this to increase the range. (IWM Q60176)

24in-long, 3.5in-calibre seamless steel tube plugged at the lower end, and fitted to a baseplate or spade. A bipod fitted with a simple elevating-screw mechanism was clamped to the barrel; improvised 'jam-tin bombs' were loaded from the muzzle, and a propellant charge was ignited by way of a touch-hole near the base. In modified form the Indian Pattern was subsequently officially manufactured in the UK as the Ordnance, Muzzle Loading, 3.7in Mortar, before being replaced in early 1916 with the excellent weapon designed by Wilfred Stokes. Stokes's '3in'-calibre mortar (actually 3.2in/81mm) used a similar tube, bipod and baseplate to the Indian Pattern, but the propellant charge was contained in the tail of the bomb and ignited by a firing pin in the base of the barrel.

The Indian Pattern and Stokes represented one evolutionary strand, which gave the infantry its own indirect-fire support weapon. Another led from the Coehorn mortar, through designs such as the Vickers 1.575in and Woolwich 2in mortars (based on a pre-war Krupp design, and firing stick-mounted, spherical 50lb 'toffee apple' bombs), and on to 'medium' and 'heavy' weapons operated by the artillery. In April 1915 a Capt Henry Newton was ordered to set up a workshop to construct specialist trench-warfare equipment, including grenades and mortars, for the British II Corps. Newton's mortars were more traditional and immobile than the Indian Pattern or Stokes designs; featuring heavy wooden beds, they were able to withstand repeated firing, and were well suited to static trench warfare provided they were deeply dug-in to protect them from counter-battery fire.

During 1915 the artillery of each British division gained three batteries each of 4 trench mortars, designated 'X', 'Y' and 'Z' Batteries, and subsequently reorganized as two batteries of 6 mortars ('X' and 'Y'). The purpose of 'trench artillery' was to harass the enemy, destroy his positions and prevent him working on his defences, as explained in the US Army's *Textbook of Artillery, Including Mobile, Anti-Aircraft, and Trench Materiel*, published shortly after the war:

> The light [trench] mortar's effect against material is inconsiderable, but is particularly effective against massed troops, or troops driven into the open, due to its rapidity of fire. These mortars are used to form a barrage behind the hostile line to prevent reserves and ammunition being brought up. Owing to their high mobility, limited only by the difficulty of ammunition supply, they are especially fitted to accompany the infantry as it advances, and are used to attack machine-gun shelters and other points which have temporarily checked the forward movement of the infantry.
>
> The medium trench mortar, with its range of approximately 1200 meters, is very effective against wire entanglements, machine-gun shelters, strongpoints, trenches, and other similar objectives not too strongly protected. The heavy trench mortar is designed for the attack of heavily protected shelters and dugouts, trenches, machine-gun shelters, and strongpoints. It is seldom used against wire entanglements because of the large crater formed by the explosion.

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While the Germans had started the war already equipped with *Minenwerfers* these were only held in small quantities, and at first they remained the responsibility of the *Pioniere*. The *Minenwerfer* batteries were distinct both from the infantry they were supporting, and the artillery, of whose fire-planning they should have been a part. In 1914 each German infantry division had an attached *Minenwerfer* company, with 3 heavy (25cm calibre), 6 medium (17cm) and 12 light (7.6cm, *Granatwerfer*) weapons. The light *Granatwerfers* were subsequently passed to the infantry, and the pioneer company was reorganized to operate 4 heavy and 8 medium weapons.

Neuve Chapelle

The Battle of Neuve Chapelle (10–13 March 1915) was the British Army's first carefully planned, deliberate attack of the new age of positional warfare. Preparations included aerial reconnaissance, which enabled the production of up-to-date maps, and experiments to determine the weight of shrapnel fire required to cut the belts of barbed wire that lay in front of the German trenches. On the day, a 35-minute bombardment cut the wire and enabled the British infantry to swiftly capture the first two lines of trenches, but this initial success was squandered as the attack lost momentum. Much-needed artillery support on targets in depth failed to materialize; the German reserves were able to dig in behind the captured trenches, and stabilized the situation. The British failures were due in large part to the difficulty of communications that depended on fragile telephone wires. By 15 March the collapse of British command and control, and chronic shortage of artillery ammunition, forced Sir John French to halt the offensive. The resulting 'Shell Crisis' helped to bring down the government, leading to the formation of a coalition with the future Prime Minister, David Lloyd George, as Minister of Munitions.

British artillery-piece production, August 1914–November 1918

Year	*New manufacture*	*Repaired & returned to service*	*Converted*	*Manufactured in USA for UK*	**Total**
1914	91	185			276
1915	3,226	395	36	189	3,846
1916	4,551	758	59	396	5,764
1917	6,483	2,957		598	10,038
1918	10,680	4,873		213	15,766
Total:	**25,031**	**9,168**	**95**	**1,396**	**35,690**

In 1914 British industry had produced 91 artillery pieces and repaired a further 185 – a total output of 276 guns. In 1915, 3,226 artillery pieces were manufactured, 395 repaired and 36 converted – a total output of 3,657. The successful conversion of the British manufacturing base to a total-war economy is illustrated in the table above; this also indicates the vast increase in the size of the RA. The ammunition consumption by massed QF artillery exceeded anything that could possibly have been imagined before 1914. To illustrate, the standard British shrapnel delay fuze for 13-pdr RHA and 18-pdr RFA field guns at the outbreak of war was the No. 80 time fuze. Manufacture pre-war was approximately 55,000 per year; by 1918 a single manufacturer was outputting 250,000 *per week*; and total wartime production of the No. 80 amounted to some 70 million, among 182 million fuzes of all types.

* * *

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German infantry on the Somme, 1916, manhandling an *Infanterie-Geschütz*, as introduced to infantry assault tactics by *Sturmabteilung Rohr* in the Vosges Mountains in late 1915. A captured German document on *Assault Battalions*, translated in April 1917, recommended the use of infantry guns against targets that could not be reached by artillery from greater distances, either because of their small size or their location: 'particular parts of the trenches, protected machine guns, flank defences, posts of sharpshooters, observation posts, etc.' (IWM Q54410)

The battles of spring 1915 were characterized by short, sharp bombardments immediately before the assault infantry went 'over the top'. While this was partly due to the shortage of ammunition (the first day of Neuve Chapelle consumed one-third of the British First Army's stock of field-gun shells), it was also the established tactic. Broadly, it worked – but it failed to take account of enemy defences in depth. The Germans quickly investigated technological solutions to break the stalemate, including poison gas (used for the first time on the Western Front in April, during Second Ypres), and flamethrowers. But while these innovations created brief tactical advantages, their overall effect was simply to make trench warfare even more frightful and the Allies more vengefully resolute.

In September 1915 the Allies once more tried to smash a hole in the German front; French forces attacked in Champagne, and the BEF at Loos. The British lacked sufficient artillery for their six divisions to batter their way through the German lines (although poison gas was used to compensate for the shortage of guns), and arrangements to bring reserves forward were poorly thought-out. This failure cost Gen Sir John French his command, which passed in December to Gen Sir Douglas Haig.

Stormtroopers and infantry guns

As the trench stalemate became established early in 1915 the Germans had some success with limited infiltration attacks, prepared by fierce bombardments and led by assault engineers. In January 1915, near Soissons, a tightly co-ordinated attack by the German 5th Inf Div seized three lines of French trenches, secured the important high ground of the Vregny Plateau, and captured artillery, machine guns and over 5,600 French prisoners. It was the use of artillery to stun and demoralize the troops holding lightly constructed French trenches that had the most profound effect on the Allies, who believed copying this method would provide the key to breaking through the German lines.

For the Germans, the lesson was that infiltration tactics worked when crossing No Man's Land, and were sufficient if the bombardment had broken the enemy's will, but that special tactics and equipment were required to defeat resolute defenders. This led to the assembly, in March 1915, of an experimental *Sturmabteilung* ('assault detachment') from the pioneers of VIII Army Corps. Named *Sturmabteilung Caslow* after the major commanding it, the unit comprised an HQ, two pioneer companies, and a generously equipped battery with 20 Krupp 3.7cm light assault guns *(Sturmkannone)*.

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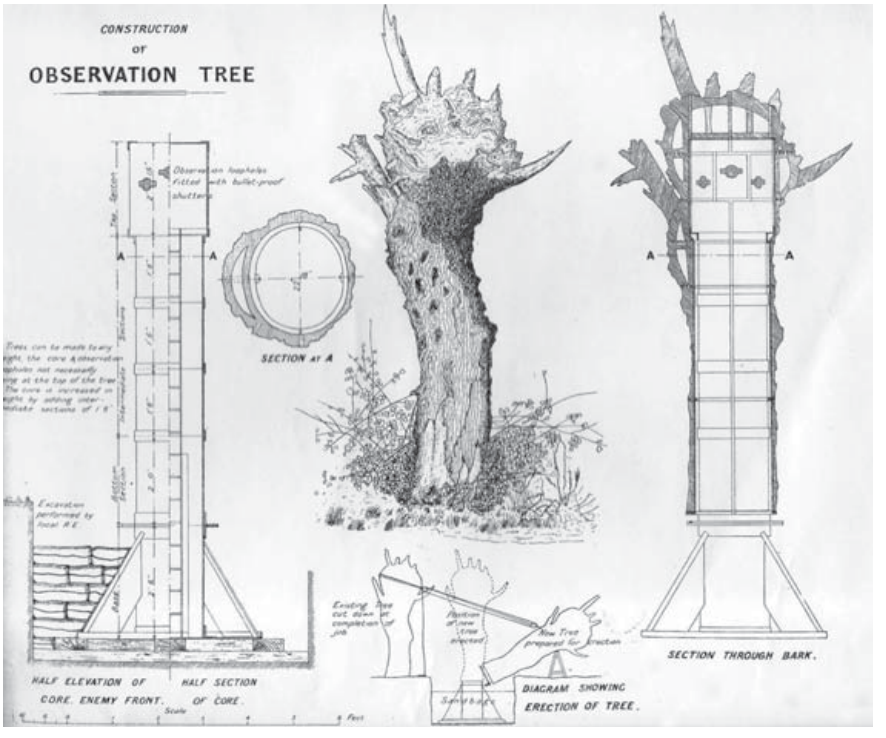
The new unit trained and developed its tactics during April–May 1915, but that summer it was unwisely deployed to the front in a defensive role, with the assault guns misused as trench artillery – for which task their bright muzzle flash made them too conspicuous.

After this initial mishandling the *Sturmabteilung* was transformed by a new CO, Hauptmann Willy Rohr, who enjoyed the full backing of his commanding general. A career infantryman, Rohr began retraining the detachment as an elite infantry assault unit. The *Abteilung* received a two-gun '08 Maxim MG platoon, a trench mortar platoon (4 light *Minenwerfers*), and a flamethrower platoon (6 two-man manpack flamethrowers). Rohr replaced the Krupp *Sturmkannone* with harder-hitting *Infanterie Geschützen* ('infantry guns') converted from captured Russian 76.2mm fortress guns.

The development of this class of weapon reflected the same requirement that led the British to develop their trench mortars. The field and heavy artillery now massed in the rear was a devastating but blunt instrument. Operating generally to pre-planned timetables, it lacked the flexibility to engage targets of opportunity or deal with unexpected resistance. A single well-placed machine gun missed by the preliminary barrage could devastate an infantry assault, but by acquiring the intimate support of guns light enough to be wheeled right forward the infantry had the firepower to destroy the fieldwork strongpoints in use at that time. Rohr tested his equipment and techniques during a limited attack on a French position in the Vosges Mountains in October 1915, and by December the *Sturmabteilung* was running courses for cadres from other units.

The Hartmansweilerkopf

The new year began with a small but important infiltration operation by Rohr's *Sturmabteilung* on 10 January 1916, again in the Vosges Mountains.



Royal Engineers notes on the construction and emplacing of a dummy tree observation post. The structure is built up from the bottom with 30in, 24in and 18in steel tube sections on a base sandbagged into a pit. The observation loopholes in the top section have pivoting bulletproof shutters. The dummy was hauled up onto its base with cables anchored to the real tree it would replace, then the latter was felled. (By kind permission of the Institute of Royal Engineers)

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The entrance at the base of a canvas, mesh and steel tree OP photographed at Souchez, May 1918. (IWM Q10309)

The objective was French positions on the Hartmansweilerkopf ridge, and Rohr insisted on detailed rehearsals, the use of briefing models, and the issue of large-scale maps. The *Sturmabteilung* manoeuvred in squads *(Stosstruppen)* led by NCOs, with support from trench mortars, machine guns, flamethrowers, and local artillery.

Typically, divisional artillery at the time consisted of 12x 10.5cm light field howitzers, and either six batteries of 6x 7.7cm field guns or nine batteries of 4 guns. In addition there was support from heavy artillery at corps or army level; a division might have the additional benefit of 12x 15cm heavy field howitzers, 4x 21cm 'heavy mortars' (siege howitzers) and 8x 15cm heavy field guns from the foot artillery. On the day of Rohr's operation a German 'box barrage' sealed off the sides and rear of the area under attack; CB fire suppressed French artillery; and a preparatory bombardment kept the defenders' heads down while the assault troops crossed No Man's Land. Well supported by fire in the right places at the right times, the *Sturmabteilung Rohr* successfully led two infantry regiments onto the objective.

1916: THE WAR OF ATTRITION

VERDUN

The 'innovations' in the use of artillery that had emerged in 1915, and which would be extensively employed in 1916, were in fact already established techniques; they could now be exploited for their maximum value simply because the front was stationary, the guns were massed, and communications were relatively reliable. The planners were thus able to bring fire to bear when and where they wanted (although this was not the same as the assault troops getting artillery support whenever and wherever they actually *needed* it – which is why they had adopted trench mortars and infantry guns). Both high commands had now become convinced of the almost limitless effectiveness of large concentrations of artillery.

C

PERISCOPE OBSERVATION POST; YPRES SALIENT, JULY 1916

The French and later the British used periscopes for observation from inside dugouts in the front lines. Periscopes could be at or near ground level on commanding ground, or hidden by a ruined wall, a tree or a telegraph pole. French periscopes, also used initially by the British, were made 2m or 3m long; the British optical instrument makers Ross subsequently manufactured them to 7ft 6in and 10ft 6in lengths. OPs were prefabricated from kits, with sandbag roofs proof against shell splinters; 2ft 8in of 'best concrete' was needed to protect observers from a heavy shell, but this was considered too obvious unless the OP could be hidden in a ruined building.

The illustration is based on sketches of an OP codenamed 'Choat' emplaced at Invers Lane near Ypres, for a heavy artillery battery supporting the Canadian Corps. A deep well, lined with iron pipe, has been bored down to allow the 10ft 6in periscope to be lowered for cleaning or protection from fire. The 5ft-high wooden cabin roofed with quarter-inch steel (shown here cutaway) was constructed off site, as was a hollow replica of a real fir tree growing in the spot selected, using detailed drawings and a scale model for guidance. A large square pit was dug behind the real tree, connected to a communication trench by a sap. Once the cabin and dummy tree had been brought up, both were installed, and the real tree was felled, under cover of darkness.

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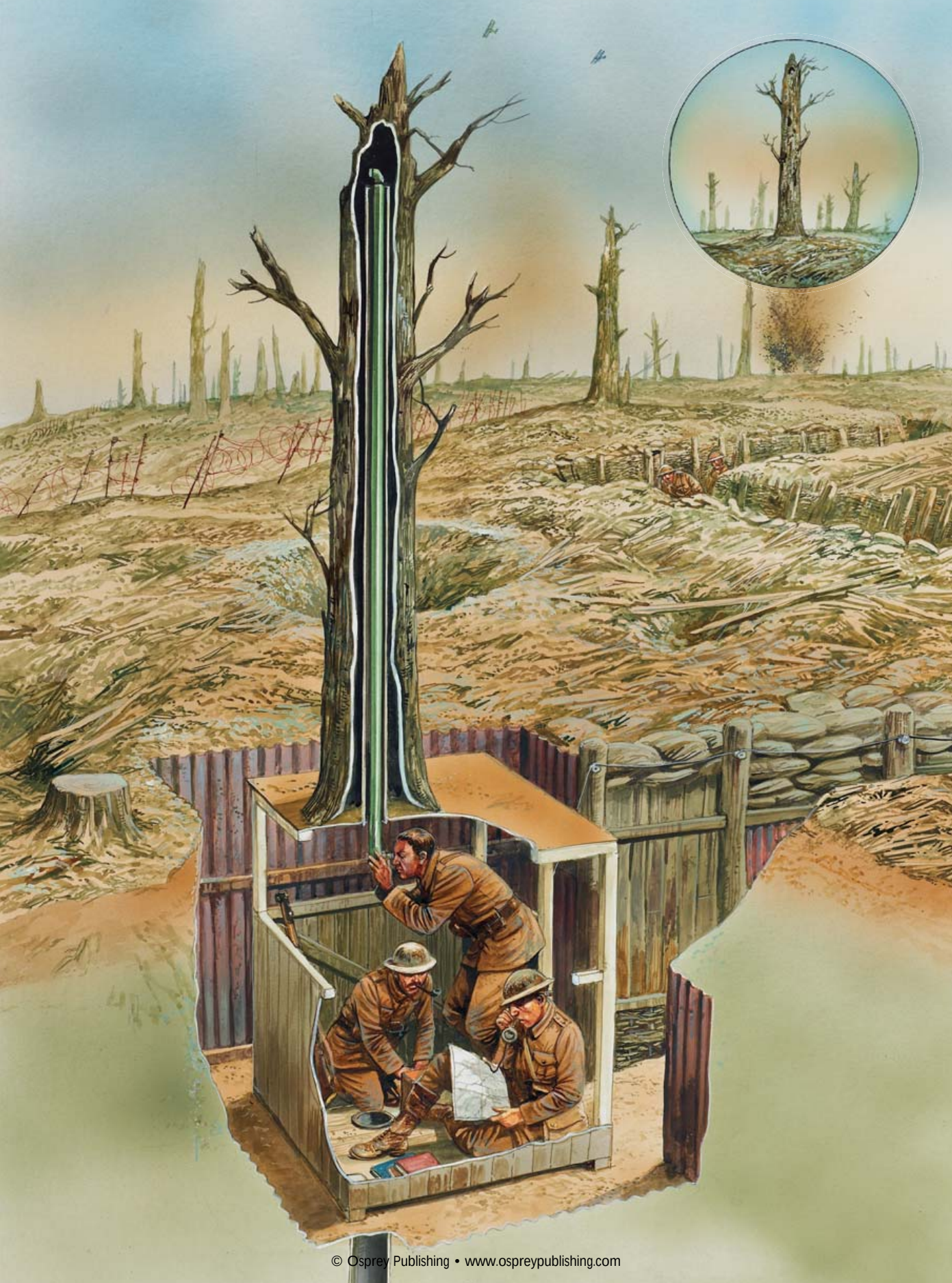

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German 15cm gun in action. For the attack on the Verdun Fortified Region the Fifth Army's artillery commander, Gen Schabel, divided his massive force of guns and howitzers into three sectors, each commanded by the senior artilleryman in one of Fifth Army's three corps. These officers controlled their corps' heavy artillery plus the divisional field artillery in their sectors. Schabel ensured co-ordination between the three sectors by reviewing their fire plans, and retained personal command of the super-heavy siege artillery. (IWM Q42435)

The Battle of Verdun (21 February–18 December 1916) was planned from the outset as a campaign of attrition, designed to inflict unendurable casualties on the French Army, weaken French morale, and undermine the relationship between the Allies. The new German chief of staff, Gen von Falkenhayn, decided to attack the fortified locality of Verdun on the east bank of the Meuse, which had held out against the German advance in 1914 and now jutted into the German lines. It was a militarily elegant choice: France could not afford to let Verdun fall, but the shape of the salient meant that the Germans could bombard the defenders from three sides, while its position on the enemy bank of a major river made re-supply difficult. In Falkenhayn's concept, all that was needed was to threaten Verdun sufficiently to provoke the French to pour reinforcements into the salient, where they could be annihilated by the artillery fire of the Fifth Army.

Persuaded by the fall of the Liége forts that their own fortresses could not stand against the German siege train, the French had stripped the Verdun forts of most of their guns, and had even planned to demolish them to deny them to the Germans. The defenders of the *Région Fortifiée de Verdun* took up positions outside the citadel and the smaller outlying forts in the surrounding woods and villages. Verdun was therefore, almost uniquely on the Western Front, a defensive position selected by the Allies, and prepared with deep trenches and concrete emplacements. However, much work remained to be done to complete the defences; the region had lost much of its mobile artillery and reserve ammunition; the forts were manned by little more than caretaker garrisons; and the troops in the salient were mostly older reservists.

Against them, Falkenhayn massed the greatest weight of German artillery ever seen – 1,612 pieces of ordnance under the command of the Fifth Army's senior artillery officer, Gen Schabel. In addition to the artillery, the divisional *Minenwerfer* companies of the nine divisions committed to the operation were bolstered by three *Minenwerfer* battalions from the reserve. It was intended to seize the hills overlooking Verdun, thus forcing the French to counter-attack this easily defended high ground, only to be repeatedly crushed by artillery fire that would 'bleed them white'. An enormous stockpile of shells was assembled – enough to fire more than 2 million rounds in the opening bombardment – and newly laid railway tracks would ensure that the

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ammunition kept flowing to the guns. In the initial attack the field artillery, *Minenwerfers* and heavy siege pieces would engage the nearest French trenches, while 15cm heavy field howitzers fired on the second line. Along with heavy guns, these would also fire counter-battery missions, and interdiction missions against targets deep inside the salient.

Some field guns were positioned near the start line to provide intimate support for the assaulting troops (*Begleitbatterien*, 'accompanying batteries'), but the cutting of barbed-wire entanglements was the responsibility of the pioneers, as was the destruction of stubborn MG emplacements by means of flamethrowers. German infantry were extensively trained for what was intended to be a series of limited attacks designed to draw French reserves into the salient.

The barrage commenced at 0812hrs on 21 February and continued for an entire day. A deliberate lull at midday allowed German reconnaissance planes and patrols to assess the damage, and tempted the defenders out of their shelters, only for the terrible bombardment to begin again. Reconnaissance reported widespread destruction, and French troops fleeing to the rear. On 22 February the artillery changed to suppressing fire, keeping the defenders' heads down as the German infantry attacked the first line of French defences. Field artillery and *Minenwerfers* were placed under operation control of the infantry they were supporting. Grenade-throwing stormtroopers attacked the battered French positions, followed by a skirmish line of riflemen, and a third wave carrying ammunition and defence stores to consolidate captured positions.

Although the massive preliminary bombardment had caused devastation, it had also made the terrain particularly difficult for the attackers, and those French troops who survived and remained in their positions took maximum advantage of the torn-up ground, tangles of fallen trees, rubble and ruins. As early as the third day the character of the German operation began to change, as the 6th Inf Div was ordered to attack the Herbebois Woods 'without regard to casualties'. Although Falkenhayn's concept had been for a 'stand-off' operation, with the French being drawn into an artillery killing-ground, the instinct of his officer corps when attacking was to push on regardless of casualties, to seize ground and defeat the enemy. German infantry attacks ceased to be limited; Falkenhayn found himself locked into an attritional battle for ground, and the 'Mill on the Meuse' began to grind Germans as well as Frenchmen.

The initial German attacks were nevertheless rewarded with remarkable success, cutting through French defences on the eastern side of the salient and seizing Fort Douaumont on 25 February. This most formidable of the Verdun forts – almost 10km behind French lines – fell with barely a shot fired when its small garrison capitulated. The Allied C-in-C Gen Joffre, determined to reduce the momentum of the German attacks, forbade any further withdrawals, and placed Gen Pétain of

A French M1913 105mm gun in a position supporting the Verdun Salient, 1916. One of Gen Pétain's first priorities in February 1916 was organizing a co-ordinated artillery effort to support the shaken infantry, and this proved effective during the vital battles of early March, destroying many of the German heavy *Minenwerfers* and a major ammunition dump, and inflicting massive casualties on German infantry attacks. In the June fighting German counter-battery bombardment with diphosgene 'green cross' gas shells badly hampered the French gunners, but by July they had received improved gasmasks, and the opening of the Somme offensive reduced German artillery ammunition supplies to Verdun. By the time the counter-offensive opened on 19 October with the heaviest French preparatory barrage yet mounted, the French enjoyed superiority both in the air and in artillery – 650 guns against 450–500 German – including two 400mm railway guns to bolster 370mm siege howitzers. (IWM Q69619)

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Second Army in command of the defence, which was heavily reinforced and stiffened with plentiful artillery.

The successful German assault on the eastern side of the salient was followed by an attack on the western side on 6 March. This was halted, and the French were ordered to counter-attack, making the recapture of every lost metre of ground a matter of national pride. The Germans also failed to cut the last remaining supply route into the salient from Bar-le-Duc, despite intense artillery interdiction. Pétain's excellently organized motor transport and road-repair efforts kept reinforcements rotating at 15-day intervals, and supplies flowing – typically, 90,000 men and 50,000 tons every week, mostly by night. The German attacks continued during April–May, with features such as the 'Mort Homme' and Hill 304 changing hands several times at terrible cost in hand-to-hand fighting, but the Germans did not achieve anything like the spectacular success that had accompanied the February assaults.

The French had been forced by the relentless pressure of German attacks and bombardments to adopt defence in depth, with small, mutually supporting defensive positions hidden in the ruins left by the bombardment, and troops sheltering in deep cellars and bunkers. This represented a challenge to both the German infantry and the artillery, which no longer had well-defined lines of trenches to bombard into submission or seal off with box barrages. Not knowing where French machine guns might be hidden, the initial German response was to employ longer preliminary bombardments, by more and heavier artillery – for example, the bombardment of the village of Douaumont in late February lasted 5 hours, and included the use of 30.5cm and 40cm siege pieces.

The 'rolling barrage'

Once a bombardment stopped there was a pause before assaulting infantry arrived on the objective, which gave the defending machine-gunners and riflemen time to resume their positions. The solution arrived at was a 'rolling barrage', a variation of pre-war *tir progressif*. This was a linear barrage – in effect, a curtain of shells – fired into the enemy's positions, and then moved forward in a series of 'lifts' of 100m or 200m as the infantry advanced. The lifts were ordered by fire controllers – artillery officers or NCOs accompanying the infantry – using telephones, flares or rockets. The intention was that rather than trying to destroy the defenders, the artillery would keep them under cover and unable to fire while the attacking infantry advanced.

Verdun: near Fort Vaux, a German infantryman takes up a fire position next to a dead *poilu* partly buried by a shellburst. By the end of 1916 the opposing armies had discovered that there always came a point when all the damage that artillery could do had been done, and that bombardment alone could not defeat a determined opponent. Despite the indescribable horror to which they were subjected, whenever the rain of shells paused the survivors would emerge from their holes, set up their machine guns, and fight back; the French did it at Verdun, and the Germans did it on the Somme. (IWM Q23760)

June saw another German offensive, which capitalized on deliveries of 'green cross' diphosgene gas shells against which the gasmasks of the period offered no protection. Attacking divisions were reinforced with additional heavy artillery, and pioneers and stormtroopers to lead the assault. In the east of the salient, Fort Vaux fell to them on

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9 June after it had been blasted to pieces by heavy artillery. Diphosgene was used only in the preparatory bombardment and against depth targets, because of the threat residual gas posed to attacking troops. Along a 5.5km front German infantry advanced behind rolling barrages of conventional shells, and nearly drove the French to the Meuse, but even the rolling barrage proved to have shortcomings. It tended to 'get away' from the advancing infantry if they were unexpectedly held up, or – as happened at Fleury on 26 June – if the barrage 'stalled' on the objective, holding up the advance, because the infantry were unable to pass the signal for it to be lifted. Artillery observers accompanying attacks were given rockets, flares, telephones, even carrier pigeons to contact their batteries; but men became casualties, equipment was broken or lost, and smaller flares and rockets could not be seen in the dust and smoke of battle.

The most basic form of artillery observation: German officers in a ground-level OP in the Bapaume-Péronne sector, November 1916. (IWM Q55200)

Determined resistance and effective support from French artillery halted successive German attacks. After the Russian 'Brusilov Offensive' in the East rolled back the Austro-Hungarians in early June, 15 German divisions had to be taken from the Western Front to stabilize the situation, and from 1 July the British offensive on the Somme drew more German reserves away from Verdun. Falkenhayn was replaced in supreme command by Hindenburg on 29 August, and German forces in the West switched to the defensive. In the autumn the French at Verdun attacked again, using a 'creeping' barrage lifting 100 yards every 4 minutes; they retook Fort Douaumont on 24 October, and Fort Vaux on 2 November. By December the French had retaken almost all the ground lost since February, capturing 11,000 prisoners and 115 guns that month. In total the battle had cost almost a million casualties – more than 540,000 French and 430,000 German – of whom about 162,000 and more than 100,000, respectively, were killed or missing.

The ten months of unbelievable carnage make it difficult to objectively examine Falkenhayn's original concept. It is important to note that, barely 18 months after the start of the war, a commander-in-chief was planning to achieve victory primarily through the use of artillery, rather than seeing it as a useful adjunct to the main effort of an infantry assault; but it is also significant that by the third day of the attack this concept was already starting to be disregarded in practice. French losses at Verdun did put pressure on the Allies, and dictated British decisions; they also succeeded in damaging the morale of the French Army, planting the germs of the mutinies in 1917. However, the long ordeal at Verdun did at least as much damage to the German Army.

SURVEY & ARTILLERY SCIENCE

British RFA officers of the pre-war era were hard-riding types, who prided themselves more on their horsemanship than their advanced grasp of artillery technology. (When one pre-war officer suggested that deploying field batteries might take a barometer to determine air pressure, he became a standing joke.) In theory, all things being equal, if the same setting was put on the sights and range dials of a battery of identical guns, then the shells should

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A German tethered observation balloon being readied for an ascent, 1916. The original successful design for a fin-stabilized balloon was by the French Capt Caquot, and this was also manufactured by the British and Americans; in their turn, the Germans copied a captured British Caquot Type M as the model for their Ae 800 balloon. (IWM Q54447)

land in a neat row exactly the specified distance from the front of the battery – and this was essentially the basis for battery fire prior to 1914. The fact that this sometimes did not happen explains the RFA's unfortunate nickname among infantrymen of 'the Drop Shorts'. To avoid needless casualties, the RFA would have to learn from the 'slide-rule gunners' of the RGA how to achieve an unprecedented degree of precision.

Apart from the importance of knowing exactly where the battery and target were in relation to one another, variables affecting the flight of shells included the temperature of the propellant charge, winds at different altitudes, barometric pressure, and the characteristics of each individual gun – particularly barrel wear. This meant that a battery fire plan would involve both different settings for every gun based on pre-recorded data (known as calibration) to ensure the shells arrived in a line, and accurate timing across the entire formation to ensure (in a spring-powered, analogue era) that they arrived when they were expected.

The BEF had arrived in France with a Printing Company RE, to distribute Army maps which were drawn in the UK. A 'ranging section' was added late in 1914, and this became 1st Ranging & Survey Section in early 1915, with the addition of topographers from the Ordnance Survey. This was subsequently expanded into three Topographic ('Topo') Sections, one for each British army on the Western Front, which had the capacity to draw and print maps in the field. In 1916 the organization was further expanded into three Field Survey Companies, which included specialist sections for survey, map compilation and drawing, printing, observation, and sound-ranging. By 1918 each of these companies had expanded to battalion size, supported by special depots and 'Maps GHQ'.

Survey behind friendly lines was by triangulation, while aerial photography was used to survey enemy-held territory. During 1915, heavy batteries were 'surveyed in' – exactly located on accurate maps, and given bearings to aiming points, and ranges and bearings to known targets – by the RE Field Survey Section. Battery positions could also be surveyed before their occupation, and bearings marked with numbered iron posts ('bearing pickets', BP). The British adopted a French innovation, the 'artillery board', on which was mounted a map or grid showing the aiming points and targets already plotted for the battery to use as soon as it reached its new position. This enabled a battery to be in action and firing with reasonable accuracy very

A Royal Flying Corps sergeant demonstrates the use of a Type C aerial reconnaissance camera fitted to a BE2c aircraft, 1916. This technology was valuable to planning staff at operation level, but artillery counter-battery fire missions depended on 'real time' observation. Correcting artillery fire from the air was a lengthy procedure, involving the pilot flying back and forth between the gun battery and the target. After plotting the fall of shot on a clear 'clock-code' disc placed over their map, the aircrew had to fly back close to the battery position and pass corrections by Morse code over a one-way wireless transmitter, whose ground-based short-wave receiver was difficult to tune. Any instructions from the battery had to be signalled to them with panels laid out on the ground. (IWM Q33850)

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soon after arrival, and the system was soon extended from the heavy to the field artillery.

The 'observation' and 'sound-ranging' sections were formed to locate enemy batteries, but also proved useful for directing and calibrating British artillery. Even in daylight, firing an artillery piece produced a flash that was visible from a considerable distance, while at night the flash was reflected in the sky. Soldiers on all sides quickly realized that it should be possible to triangulate the position of an enemy battery by taking bearings on the flash from a number of locations and plotting where the resulting lines on a map intersected. But achieving a reasonable degree of accuracy required the OPs to be as widely separated as possible (initially, British OPs were positioned as much as 2 miles apart), and this raised the familiar problem of communication. How was it possible to ensure that the OPs were observing the same battery firing at the same time?

A French mobile darkroom processes aerial reconnaissance photos in the aviation camp at St Amand on the Aisne, November 1917. Once a pilot committed to a photographic run over a section of the front, he had to fly straight and level to secure a whole series of overlapping photos to create a mosaic. Their predictable patterns of movements made all reconnaissance aircraft vulnerable to enemy AA artillery and 'scouts', and it was normal for one spotter plane to be escorted by up to a whole squadron of fighters. (IWM Q69047)

Flash-spotting

This technique was attempted with little success in 1915, but in 1916 a Maj H.H. Hemming devised the 'flash buzzer board', a crucial element of a highly effective system that was later also adopted by the US Army. The combination of the flash buzzer, powerful French telescopes, and the No. 5 Director – resembling a theodolite, and used to determine accurate bearings – made British observer sections highly effective at accurately placing German batteries (see accompanying panel). By the end of 1916 flash-spotters were organized in groups of four OPs, each group reporting to a Group HQ responsible for collating their observations and feeding them into the counter-

The Flash Buzzer system

Writing in the late 1960s, Lt Col H.H. Hemming described the operation of the system he devised. 'Ack' and 'Bea' were the contemporary phonetic alphabet for 'A' and 'B':

Imagine a small 'straff' at night, with five German batteries firing on our trenches. One post, say 'Bea', gets on to a flash, and as soon as the observer has seen it through his Director he presses his key. That causes his lamp to light on the HQ switchboard and his buzzer to give quite a buzz, which is heard not merely by the HQ telephonist but also in the earphone of the observers in the three other observation posts. The plotting board NCO at H.Q. then tells 'Bea' to lead, and the telephonist switches off the buzzers from the other three posts. He also asks 'Bea' for its bearing. The NCO plots that bearing on the plotting board, and is able to get a pretty shrewd idea of roughly where the battery in question is located. He gives the other three posts approximate bearings at which to look. Two minutes later the same battery may fire another round, and this time not merely does 'Bea' observe it but also another post, say 'Ack'. That observer had pressed his key and his lamp had lit up. When three or four posts are all observing the same flash on which 'Bea' is 'leading', and all the lamps are lighting together, the Plotting NCO turns off 'Bea's' buzzer. If all the lamps still light simultaneously he knows that it is a completely genuine fix, and that one of the posts is not confusing the flash of the German shells bursting on their target with the real gun flash.

(*Artillery Survey in the First World War*, Field Survey Assoc., 1971)

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battery system. Flash-spotters could also adjust British fire onto the target; so successful was this system that from 1917 'ranging sections' were formed, using their own OPs or the regular flash-spotter OPs, to direct long-range fire from British guns.

Sound-ranging

The possibility of locating enemy batteries by sound was investigated early in the war by both the French and Germans, but not initially by the British. The principle of sound-ranging was based on the fact that firing a gun created an expanding circular shock wave travelling at the speed of sound. If a line of listening posts or microphones were set up at measured distances apart, and the exact moment that the shock wave reached each one of them was recorded, it was theoretically possible to draw a circle on the map at the centre of which was the gun. However, the accurate recording of a single 'bang' on the battlefields of the Western Front was a tall order; moreover, the actual sound of firing was a very low-frequency report, and much harder to detect than the sonic boom as a shell travelling faster than the speed of sound passed overhead.

Early leaders in this field, the French came up with a highly complex but promising system devised by Lucien Bull. This used an electrical device called an Einthoven galvanometer, and recorded its data on ciné film; while having the obvious disadvantage of needing its results to be photographically developed, it was both sensitive and accurate. However, when it came into service in February 1915 Bull's device was seriously handicapped by microphones which struggled to distinguish the low-frequency report of the gun firing from other ambient sounds.

German survey, sound-ranging and flash-spotting were organized on broadly similar lines to the British, but employing artillerymen rather than engineers. The Germans used a 'binaural' sound-ranging system, consisting of posts equipped with twin horns; when these were turned towards the sound of a battery firing a bearing could be taken, and the bearings from three posts produced a triangulation. Although simple and robust, it was primitive compared to the technology the Allies were exploring.

The British were fortunate in having the services of W.L. Bragg, a Territorial Force horse artilleryman. More talented as a scientist than a horseman, in mid-1915 Lt Bragg was sent to learn the theory of sound-ranging with a French unit, and that October he acquired a lorry-mounted Bull set. The inadequacy of the available microphones meant that for most of 1916 sound-ranging was a 'wash-out', but Bragg's little unit persevered. Eventually his equally talented Cpl Tucker succeeded in harnessing and tracing the strong air-pressure waves produced when artillery was fired

D

BOX BARRAGE PROTECTING CANADIAN RAID; VIMY, APRIL 1917

During the intense bombardment that preceded the Battle of Vimy Ridge, Canadian 1st Div planners became concerned that the artillery fire was not cutting the barbed wire in front of the German trenches; this would further hamper an attack that would already have to negotiate large craters. In the early hours of 8 April, Acting Capt Stanley Kent of 10th Bn, Canadian Expeditionary Force led a raid by 85 men in three parties **(1, 2 & 3)** some 150 yards into the German front-line defences **(GFL – GFL – GFL)** to establish how seriously they had been damaged. (Note the characteristic German 'straight – D – straight' pattern of the trench, unlike the typical British squared-off 'key' pattern.) This raid was possible because artillery fired a box barrage **(red lines)** to seal off the section of the German trenches being reconnoitred from any reinforcement. The raiders killed four German soldiers, brought back two prisoners when they withdrew **(inset),** and established that further bombardment by heavy howitzers was indeed required. The cost was five Canadians killed and 13 wounded, but the intelligence gathered was judged to have saved many more lives in the subsequent attack.

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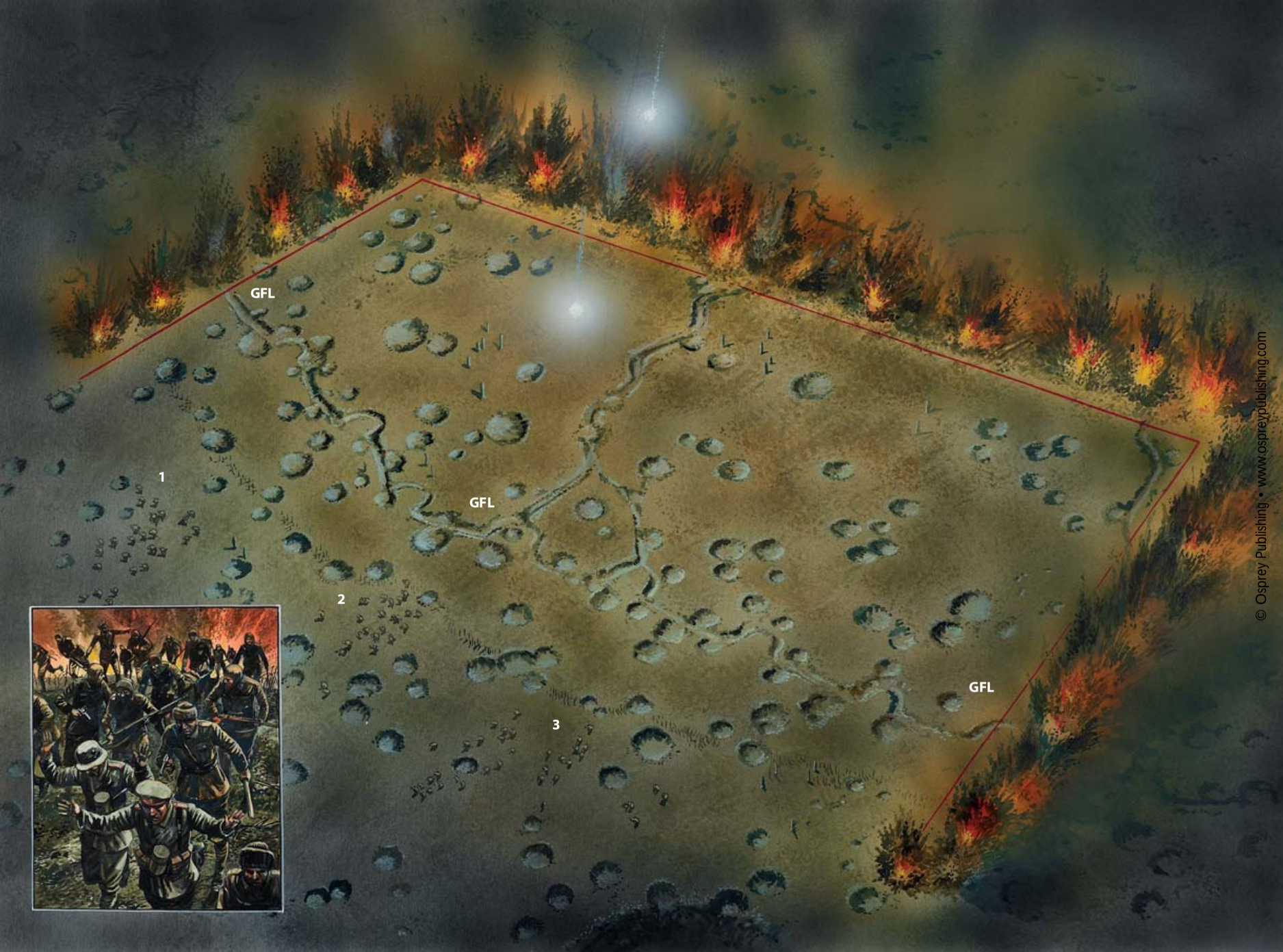

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(sudden changes caused by sonic booms disturbed the air much less than this initial powerful 'push'). When coupled with the Bull system, this ingenious 'Tucker microphone' enabled a skilled operator to interpret a huge amount of data, and even to locate multiple batteries firing at the same time. After a late and hesitant start, the British had the most effective sound-ranging system on the Western Front.

THE SOMME

What became the Battle of the Somme had been conceived by Joffre as the Allies' main joint offensive in 1916, but planning was derailed by the German attack at Verdun. Consequently, Gen Rawlinson's British Fourth Army would provide the main effort in the centre, combined with limited attacks by VII Corps of Gen Allenby's Third Army on his left, and by XX Corps of French Sixth Army on his right. The British C-in-C Gen Haig ordered his armies to prepare for an attack by 25 divisions on a front of 25,000 yards, to a depth of one and a half miles. Haig was confident that his forces could punch a hole in the German front-line and support-line defences, through which he could move his cavalry and resume manoeuvre warfare. Rawlinson was more cautious; but both generals agreed that a sufficiently devastating artillery bombardment should allow the infantry to walk through the German front lines almost unopposed. They underestimated the German defences, which were unlike anything the British had encountered previously. A huge belt of barbed wire would be difficult, time-consuming and expensive to cut through with gunfire; MG posts were strengthened with concrete, and the defending troops were sheltered in large, elaborate dugouts deep below ground.

The Somme would be the first British operation in which Operation Orders & Instructions dealing solely with artillery were issued from army headquarters by the Major-General Royal Artillery (MGRA), MajGen Noel Birch. A counter-battery officer was appointed as part of the MGRA's staff, with a Compilation Section to collate the data from observation by aircraft and tethered balloons, flash-spotting and sound-ranging, and other intelligence sources. Meteorological reports ('meteor telegrams') were sent out to batteries at 0900hrs, 1500hrs and 1900hrs daily, giving wind direction and speed at 2,000ft and 4,000ft above sea level; so useful was this data that, in June 1916, wind velocities at 200ft and 500ft were added.

Women war workers in the New Case Shop at the Royal Arsenal, Woolwich, in 1918. By that date the quality control for the manufacture of munitions was greatly improved, but in 1916 a rapidly expanded and largely untrained workforce was still 'learning on the job'. For example, shortly before the Battle of the Somme it was found, almost incredibly, that there was a variation in the overall length of 6in-calibre shells of as much as 4in (100mm) – with, as one post-war commentator dryly noted, 'the inevitable disturbance of ballistic factors'. (IWM Q27847)

The 'Shell Crisis' of 1915 had been resolved with a complete reorganization of the munitions industry and the creation of National Shell Factories; however, the largely unskilled workforce was turning out quantity without quality, and there were many complaints of 'dud' munitions reaching the front. A worrying proportion of 'premature' detonations were being reported by batteries, many attributed to the faulty 'Fuze, Graze, No. 100'. Since no instantaneous fuze was yet available for 18-pdr HE shells, the German barbed wire would have to be cut with shrapnel – which was much less efficient than blowing it up with HE. There was also a shortage of gas shells (in May a demand was sent to the War Office for a total of 10,000 per week for the 4.5in, 4.7in and 60-pdr pieces, but none had reached the front when the battle started).

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Nonetheless, ammunition supply now involved moving, distributing and storing enormous volumes – increasingly difficult tasks, as the poor roads in the region collapsed under the strain.

Some of the guns themselves were less than reliable. The strain of firing at unprecedented rates for prolonged periods was causing the recoil mechanisms of 18-pdrs to fail, a problem only partly resolved by re-tempering the springs. Some heavy artillery batteries were still equipped with obsolete 4.7in guns with dangerously worn-out barrels. Even older were the 30cwt 6in howitzers, which had a maximum range of only 7,000 yards; the new 25cwt 6in howitzer, with a range of 9,500 yards (11,400 yards with a lighter 86lb shell) was coming into service, but many batteries still had the older type. The 8in heavy howitzer was a stopgap design, converted from bored-out 6in coastal guns; huge wooden wedges had to be placed behind the wheels to check its recoil, which made firing both inaccurate and slow, since it had to be re-laid for every shot. Again, an improved replacement was in production, but had not reached the front by July 1916.

'Dud' – a British officer inspects a large-calibre shell that has failed to explode; the fluted marks left by the barrel-rifling on the copper driving band around its base show that it has indeed been fired. Notoriously, even nearly a century after the great positional battles of 1916 significant numbers of such duds still come to light on the old front lines in Belgium and France every year. The sheer size of the projectiles fired by the RGA and its counterparts is striking to modern eyes; for example, the British 15in siege howitzer, with a range of 6 miles, fired an HE round weighing 1,450lb – well over half a ton. (RAHT)

Gun positions were strengthened, with overhead cover for many field guns and ammunition and crew shelters for the heavy batteries. Dummy positions were also prepared in order to draw enemy CB fire, and strengthened OPs were built using prefabricated kits. The RE also laid thousands of miles of telephone wire, in the forward areas much of it in 'bury' trenches 6ft deep to protect it from the German '5.9s'. Six days' rations and water were placed on every battery position, and ammunition was stockpiled. For example, each 18-pdr had 354 rounds on the battery position, each 6in howitzer 200, and each 8in howitzer 90 rounds. Additional dumps nearby held 1,000 rounds for each 18-pdr, 650 for each 6in howitzer, and 500 for every 8in howitzer. A further 250 rounds per gun of 18-pdr were held at divisional level, and 200 rounds for each 6in howitzer in corps dumps.

British artillery on the Somme, 1 July 1916

Field artillery	*Total*	*Yards of front per gun*
18-pdr	808	30.9
4.5in howitzer	202	123.6
Heavy guns		
4.7in	32	781.2
60-pdr	128	195.3
6in	20	1,250
9.2in	1	25,000
12in	1	25,000
Heavy howitzers		
6in	104	240.3
8in	64	390.6
9.2in	60	416.6
12in	11	2,272.7
15in	6	4,166.6

Apart from the 1,437 British guns and howitzers listed above, there were also 16x French 220mm howitzers and 60x '75s' for firing gas shells, and 24x 120mm long guns for depth fire.

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The British use of mortars was rationalized in 1916. The previous *ad hoc* crews were replaced by infantry mortar detachments to operate the 3in Stokes light mortar; RFA detachments for the 2in medium ('Toffee Apple') mortars and the 6in Newton medium mortars that replaced them; and RGA detachments for 9.2in heavy mortars. In addition to these equipments, the RE used 4in Stokes mortars and Livens Projectors for chemical warfare.

The progress in technology, organization and logistics made by the Royal Artillery during the previous 18 months was real, but still immature. Although great efforts were made to learn from past experience, the output from the General Staff was vague about how artillery would be used to win the impending battle, which left artillery doctrine open to interpretation lower down the chain of command. In May, Fourth Army issued its *Tactical Notes*, which outlined the way an attack through to the enemy's second-line defences would be undertaken. The notes explained: 'The ideal is for the artillery to keep their fire immediately in front of the infantry as the latter advances, battering down the opposition with a hurricane of projectiles'.

This clearly anticipated the use of a moving barrage, and orders for 7th Div Artillery (XV Corps) added further detail, laying stress on the importance of 'keeping up a steady pace of fire which will move ahead of, and at the same rate as, our infantry'. Problems of co-ordination were anticipated because of the difficulties of observation and communication, and it was decided that the answer was a rigid timetable, with a slow movement forward to allow the infantry to keep up. (One disadvantage was that fire could not easily be called back to re-bombard a position that had been missed.) The moving barrage was now apparently part of British doctrine; but no guidance was given regarding fire on targets in depth, interdiction, or counter-battery work.

The preparatory bombardment

More guns were deployed on the Somme (see page 39) than the British had ever used before (though rather fewer, and at a lower density, than they would use in subsequent battles). The battle opened on 24 June, 'U-Day', with a preparatory bombardment that lasted seven days. There were breaks for reconnaissance aircraft to overfly the German defences and assess the damage, and extensive use was made of the French guns firing gas shells, particularly at night, in order to catch the Germans off guard and inflict greater casualties. Notoriously, however, in many sectors the barbed wire remained uncut.

1 July: the 'creeping barrage'

On 1 July the infantry attacked. Owing to the general uncertainty over the best form of artillery support, artillery tactics differed between the six corps

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'WHEELING' & 'BREAKING' BARRAGES

Barrages were laboriously worked out in advance, with detailed instructions produced for every gun firing. It was possible to achieve some astonishingly sophisticated patterns of fire using techniques such as the 'wheel' and 'break'.

(1a, 1b, 1c) 'Wheel' This replicated that drill movement by a rank of soldiers. A barrage was said to 'wheel' when the whole barrage moved forwards but changed direction. Here the extreme right-hand gun in a six-gun battery (No. 1) makes lifts of 50 yards, the extreme left-hand gun (No. 6) lifts of 100 yards, and the intermediate guns lifts adjusted to maintain an effect like a swinging door in the fall of successive shots.

(2a, 2b, 2c) 'Break' This effect was achieved by having some guns continue firing at the same relative ranges during a lift, while the others increased their intervals, thus bending the barrage in a sharp turn instead of a wheel. Here guns Nos.1–3 maintain their relative ranges for the first lift, while No. 4 has added 25 yards, No. 5 50 yards, and No. 6 100 yards. For the second lift all guns have added 100 yards.

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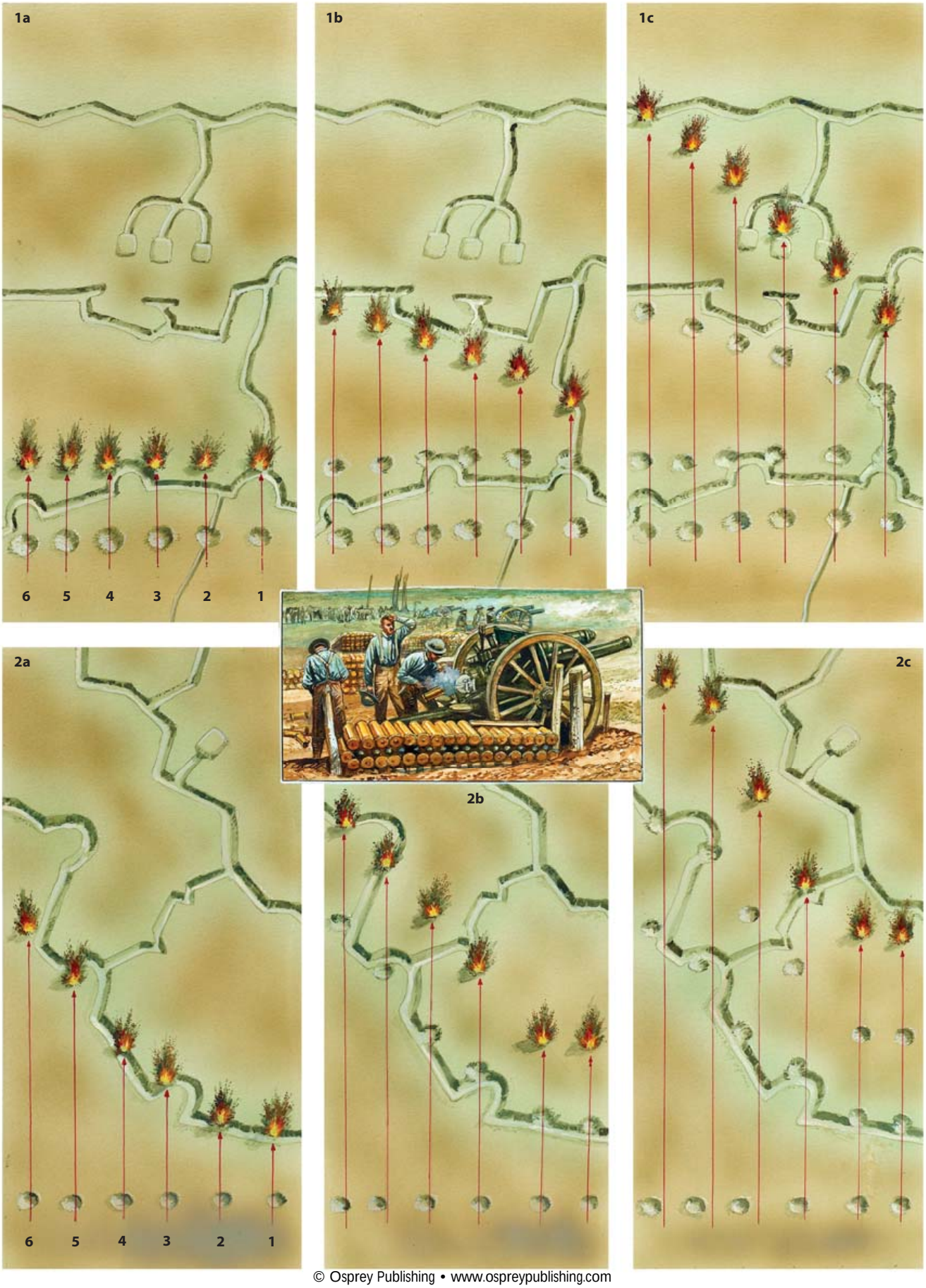

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committed, and between the divisions within those corps. In defence of the RA, it must be pointed out that the divisional commanders had the deciding vote regarding the way in which they would be supported by the guns, and the infantryman's instinct was to put the weight of fire directly on enemy positions, rather than firing into No Man's Land or the areas between lines of trenches. The following notes follow the attacking corps in order from north to south:

In **VII Corps** on the right flank of Third Army the instruction was to adopt a 'creeping method' (the first time the word 'creeping' had been applied to a barrage):

> The rate of the advance of the infantry has been calculated at 50 yards per minute… It is therefore the intention of the divisional artilleries to assist the infantry forward by lifting very slowly 50 yards each minute… The infantry therefore must make their pace conform to the rate of the artillery lifts… The success or otherwise of the assault largely depends on the infantry thoroughly understanding this 'creeping method' of the artillery… The infantry must be taught to realize that it is better to be occasionally checked rather than [that] our artillery should lift off the objective too soon, thereby allowing the enemy to get their heads up and open rifle and machine-gun fire on the assaulting lines.

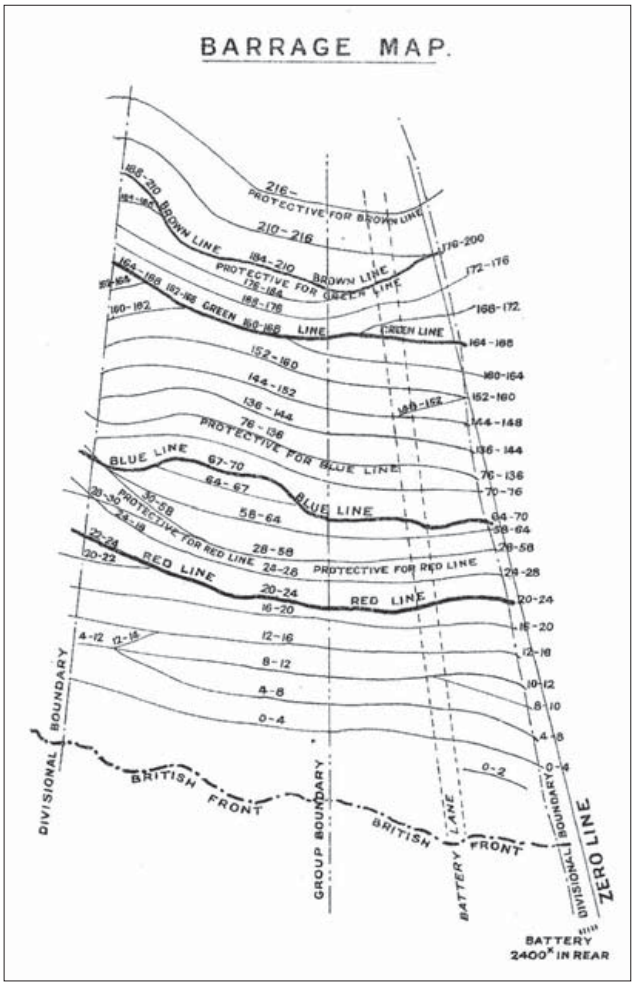

Diagram showing the timing of 'lifts' in a barrage by the Divisional Artillery, divided into two Groups (note central 'Group Boundary'). In the right half, two dotted rules mark a single battery's lane. The wavy horizontal lines mark 'lifts', advancing towards and across enemy trench-lines coded 'Red', 'Blue', Green' and 'Brown'. Up to, across and behind the first enemy line the lifts are at either 2- or 4-minute intervals until minute 28. There is then a 30-minute 'stand' ('Protective for Red Line'), sealing off the Red Line from German counter-attack. At minute 58 the barrage begins to move once again in 6-minute lifts until it gets behind the Blue Line, and so on; in all, the barrage lasts 216 minutes. (*Notes on Gunnery*, May 1918; author's collection)

This clear and well thought-out instruction shows a grasp of the need to prevent the barrage 'getting away' from the infantry, by using a 'creeping' series of slow, short lifts, and also acceptance that this might actually hold up the infantry at times. Most importantly, it assumes that, despite the ferocity of the preparatory bombardment, the enemy would still be active and dangerous, and that the role of the artillery was to suppress resistance until the last possible moment. In the event, however, the divisions in receipt of these instructions actually prepared (easier) lifts of 100 yards executed every two minutes. This was much more akin to the 'rolling' barrages used by the Germans at Verdun than the more sophisticated 'creeping' barrage envisaged in the VII Corps instruction.

In the **VIII Corps** sector of Fourth Army's front, the explosion of the mine at Beaumont Hamel 10 minutes before Zero Hour effectively announced the commencement of the attack to the Germans – a situation made worse by the fact that the heavy artillery bombardment lifted from the front-line trenches at the same time, and the field howitzers' 5 minutes later, leaving only a thin barrage of shrapnel shells. This commenced actually on the German front line rather than in

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front of it in No Man's Land, which would have given much greater cover to the infantry. As a result, they were cut down as they crossed the broad expanse of No Man's Land.

X Corps decided not to use a rolling or creeping barrage, instead lifting fire from one line of defences to the next while using a small number of guns and howitzers to 'walk' fire along intermediate communications trenches. However, 97th Inf Bde (32nd Div) used a tactic that its commander, BrigGen J.B. Jardine, had seen Japanese troops using in the Russo-Japanese War: his infantry crept to within 40 yards of the barrage on the German front-line trenches, charging in as soon as the barrage lifted and taking the enemy positions with minimal losses. However, the barrage immediately jumped all the way forward to the second line, leaving the infantry behind and exposed, and the attack ultimately failed.

A German shell bursting forward of the British wire, in a still from the contemporary ciné footage by Geoffrey Malins and J.B. McDowell which was later edited into the film 'The Battle of the Somme'. The large earth clods in the shellburst illustrate the 'burrowing' effect of HE shells, which reduced their lethality at ground level. Nevertheless, in several sectors on 1 July 1916 (e.g. that of 31st Div, VIII Corps, whose preliminary counter-battery fire had been minimal), the unsuppressed German artillery inflicted casualties on the British infantry before they even left their trenches, and continued right out across No Man's Land. (IWM Q79487)

The term used by the artillery of **III Corps** was 'raking', which apparently described the barrage first jumping forward, then rolling back towards the infantry, based on pre-war 'searching' fire. The danger of 'friendly fire' casualties was obvious, so the fire was supposed to move forward into the enemy positions faster than the infantry could advance. Inevitably this meant the barrage 'getting away', and as a result the corps attack failed.

The closest any artillery came to meeting the spirit of the Fourth Army concept for artillery/infantry co-operation was in **XV Corps**, where 7th Div artillery fired a creeping barrage with 50-yard lifts every minute. The attack on the German front-line trenches was successful, but optimistically tight timings meant that the barrage started to 'get away' as the infantry moved on towards the second objective. The decision to bypass Fricourt village left the troops on either flank enfiladed by enemy emerging from deep dugouts. This caused the creeping barrages to 'get away' from 7th and 21st Divs, with the inevitable result that the infantry attack suffered.

The **XIII Corps** instructions stated that the field artillery barrage should 'creep back by short lifts'. Again, the divisions went their own way: 30th Div used just four lifts between the trench systems, at Zero +6 minutes, +16 minutes, +56 minutes, and +146 minutes. There was some innovative thinking: the division's 4.5in field howitzers fired tear gas from Zero –5 minutes until Zero +30, at a rate of two rounds per gun per minute, but during the last minute of each lift only HE was fired, indicating to the infantry that a lift was about to take place. The 18th Div also used barrages lifting from first to second trench-lines, but covered the last 1,000 yards of the infantry advance (inside the German positions) with a true creeping barrage, lifting 50 yards every 90 seconds. The XIII Corps attack was the most successful on the day.

Counter-battery fire

As important for the infantry as their moving barrages was the British counter-battery fire that was supposed to protect them from German artillery. This had begun on 'U-Day', 24 June; the details were, once again, left up to the individual corps, and the resources devoted to suppressing German artillery varied greatly.

VIII Corps received some of the deadliest German artillery fire on 1 July. This corps had organized two CB groups comprising a total of three 60-pdr

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Battle of the Somme, 3 July 1916: steps leading down to a German underground shelter complex at Bernafay Wood near Montauban, captured by 9th (Scottish) Division. This gives a striking impression of the protection from the British bombardment enjoyed by the German defenders on the Somme. (IWM Q4307)

batteries, three 4.7in batteries, a battery of 6in howitzers and another of 9.2in howitzers, as well as three batteries of 4.5in howitzers, two of 6in guns, and a single 9.2in gun (which could send a 380lb shell 21,000 yards – nearly 12 miles). However, this impressive effort was undermined by a wholly unrealistic allocation of ammunition – 20 rounds per gun per day – and by the provision of just one spotter aircraft for CB work. The counter-battery artillery 'failed completely to dominate the German guns', which inflicted heavy casualties on the infantry.

In **X Corps** a special officer was appointed to co-ordinate CB (the first time this had been done at corps level). Plentiful artillery was allocated to the task, divided into Northern and Southern groups which totalled seven batteries of 60-pdr guns, two of 18-pdrs, and one each of 4.5in howitzers and 4.7in guns, with additional support available from 6in howitzer batteries. As in VIII Corps, this plan was compromised by an inexplicably low allocation of ammunition. On 28 June, for example, batteries fired just 6, 8 or 12 rounds at German batteries at hourly intervals. On 29 June the corps CB groups had the benefit of aerial observation, but still only fired some 150–200 rounds. Moreover, the batteries were instructed to make corrections based on 'general results' from the aerial observers, and without accurately adjusted fire it was highly unlikely that any significant damage could be done. Later, X Corps judged its lightweight CB fire to have been a serious mistake, although it should be noted that on 1 July enemy artillery fire was less of a factor in this sector than well dug-in machine guns.

In **III Corps**, two Heavy Artillery Groups were allocated to CB – 32x 60-pdrs, 8x 4.7in guns, plus 3x 12in howitzers on 'Z-Day' (1 July). The corps relied on aerial observation, and, apart from the weather problems, RFC reports of enemy battery locations were often inaccurate. It should be borne in mind that the aircrews were operating in airspace filled with huge numbers of heavy projectiles moving in both directions, anti-aircraft fire of all calibres was becoming more plentiful and accurate, and at any minute an enemy fighter might swoop out of the sun. Most features had been erased from the terrain below, and what remained could be transformed unrecognizably by a few hours' bombardment. Even when communication was established between an aircraft and a battery, and fire corrections could be passed (using the 'clockface' method), it was very difficult to determine whether the fire being observed belonged to that battery or another, and whether corrections were having any effect. Nevertheless, real efforts were made to improve co-operation by better staff work; by 4 July German artillery in the corps area was noted as being ineffective, and as the battle wore on co-operation between gunners and airmen was further refined. However, on 1 July the enemy artillery had not been suppressed, let alone destroyed, and the heavy casualties inflicted on the infantry by German guns (e.g. 250 in one battalion) were judged to be one of the key factors in the failure of the III Corps attack.

XV Corps, attacking the Mametz-Montauban salient, benefited from the effective CB work done by XIII Corps on its right (see below). This was just as well, as XV Corps had devoted fewer resources to this work – 60-pdr and

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4.7in heavy guns, and heavy howitzers 'if necessary'. On 'V-Day' (25 June) four batteries fired just 1,000 rounds in counter-battery. This was principally due to the difficulty of finding targets: instead of firing at known battery positions 'off the map', like XIII Corps, XV Corps staff officers tried to make sense of a flood of frequently conflicting and inaccurate information. Their diary noted: 'The principle difficulty in the counter-battery work was the selection of targets from the numerous pin-points from numerous sources, e.g. Intelligence Corps, Heavy Artillery, RFC, Kite Balloon, RFA Brigades, and FOs [forward observers]. Attempts to range by air observation were not successful, principally owing to the difficulty of distinguishing bursts when so many guns were firing'.

Counter-battery fire; this photo, in fact dating from the Battle of Passchendaele in late 1917, shows British troops – apparently from Hawke Bn, 63rd (Royal Naval) Div – examining a German 15cm heavy field howitzer wrecked by artillery fire in a sodden, sandbagged battery position. Even direct CB fire was of limited accuracy. It was calculated that under ideal (range-firing) conditions, a QF 18-pdr firing at a standard gunshield measuring 4ft 6in high by 5ft wide would hit with 60 per cent of its shots at 2,000 yards, but thereafter the probability of a hit dropped off dramatically: to 33 per cent at 2,500 yards, 16 per cent at 3,000 yards, and only 5 per cent at 4,000 yards. (IWM Q6047)

The most successful effort was by **XIII Corps**, which allocated more ordnance to CB fire than any other: four batteries of 60-pdrs, four of 6in howitzers, one each of 12in howitzers, 4.7in guns and 4.5in howitzers, and a half-battery of 6in guns. The batteries were tasked not merely to suppress the German guns in their sector, but to destroy them with intense fire. If aerial observation was impossible due to poor weather, then CB artillery was to fire on positions that had been registered before the bombardment started. On 26 June, 19 German batteries were engaged, and 13 on the 27th, despite bad weather. A break in the weather on the afternoon of 30 June enabled the RFC to get aloft, and 32 batteries were engaged. German batteries north of Mametz and Montauban were destroyed along with their ammunition, and the artillery of the German 12th Inf Div was badly mauled.

* * *

It is evident that, despite the huge effort put into preparing for the Somme offensive, a general uncertainty over the best way to use its resources meant that the British artillery's preparation for the first day of the attacks was a great deal less decisive than it should have been. The picture on the eve of battle is one of an army in transition. Elaborate care had been put into preparation and planning, much of which was correct in theory; but on 1 July 1916 the 'New Armies' lacked the technology, experience, and staff process to beat an enemy who was learning and evolving just as fast.

The 'first day of the Somme' was notoriously the most costly in the history of British Army – 60,000 casualties in a single day, 19,000 of them dead. The attackers had totally failed to achieve the planned breakthrough, and were left with little more than a toehold in the German defences, at an appalling human cost; but this cruel school was teaching Britain's new armies their business. The wide variety of tactics employed left staff officers with a mass of data to study, from which lessons began to emerge over the following weeks and months.

14 July: Ginchy-Pozières Ridge

An attack on the second line of defences on 14 July, using new tactics, was entirely successful, largely due to pressure from the Fourth Army MGRA,

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French heavy artillery in action late in the Somme campaign: a 240mm howitzer emplacement in the Ravin d'Harbonniere, 29 September 1916. (IWM Q80285)

MajGen Birch. The plan for 14 July involved infantry forming up in the dark in No Man's Land for a dawn attack (which many argued would be too difficult for inexperienced troops to achieve), and a 5-minute surprise bombardment instead of the traditional 30 minutes, which would alert the Germans. The 18-pdr guns and 4.5in howitzers fired HE with delay fuses, as did the 6in howitzers; the latter were also used to blast a line of craters in front of the German positions which the first infantry wave could use for cover. The infantry formed up efficiently, and the short bombardment was devastatingly heavy and accurate. The infantry were so close behind the barrage that they did suffer casualties from 'short' rounds; but they were able to fall on the confused defenders before they had time to react, taking the Ginchy-Pozières Ridge and capturing some 1,400 prisoners. Reinforcements were ready to push forward and exploit the success, but (for neither the first nor the last time) confusion at headquarters resulted in a halt just when the British had the upper hand.

Learning from disaster

While the Battle of the Somme continued until November 1916 as just another attritional killing-match, the opposing armies weighed the lessons and adapted. The British strengthened their artillery structure at corps level, while the Germans increasingly favoured a division-based structure, moving heavy artillery control down from corps to divisional command. Typically, a German division in 1916 had 12 field and six heavy batteries, although this was increased to 20 batteries at Verdun and on the Somme. The divisional area was divided into two, three or four sectors, each having a mixed group of field and heavy artillery.

Having determined that the creeping barrage was the key to mounting effective attacks, the British continued to refine the technique. The barrage used at Courcelette on 15 September 1916 advanced 100 yards in 3 minutes. When British officers examined the ground later they found German machine-gunners dead in the shell holes that they were increasingly favouring as cover; they had been killed by shrapnel, and the ideal ratio of shrapnel to HE became a subject of debate. The 15 September attack also saw the British barrage modified to accommodate a new weapon: the tank. Stationary barrages were fired on German positions to the rear to isolate the forward defences, and jumped forward to the next line when the creeping barrage reached them. Lanes 100 yards wide were left in the stationary and creeping barrages for the tanks to travel along; if the tanks should be destroyed (or break down, which most of them did), then the gaps were supposed to be filled by artillery fire, although this proved very difficult to co-ordinate.

By the standards of the campaign, the 15 September attack was a considerable success; the capture of Flers illustrated what tanks might achieve if their reliability could be improved, and if they could be protected from the fire of German artillery. The British were able to employ gas shells – 9,000 chlorine shells for 4.5in howitzers were used to bombard trench junctions, fieldworks, and the fortified villages that were hard to attack with shrapnel and HE.

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THE EASTERN FRONT

The Russian and Austro-Hungarian armies

The vast spaces of the Eastern Front swallowed armies; rather than halting in trench-bound deadlock, the war there remained a combination of grand manoeuvre with positional warfare around key points.

While there was nothing inherently wrong with Russian equipment, the country's limited industrial capacity, the need to equip a vast army, and poor and overstretched logistics meant that shortages were a constant problem. In theory, Russian cavalry divisions each had a horse artillery group of two 6-gun batteries, while infantry divisions had a field artillery brigade of six or eight batteries. While Russian field batteries enjoyed a luxurious official scale of eight guns, this might drop to six – assuming that there were any guns at all to be had, and any ammunition for them. The 76.2mm M1902 field gun was a workmanlike piece for its generation (although overall numbers were made up with the old BL Krupp 90mm M1888), and Russia's 122mm M1909 light field howitzer had a useful performance, firing a 52lb shell to 8,100 yards. A howitzer 'division' of two batteries of four or six powerful but elderly 150mm M1884 pieces was held at corps level.

Austria-Hungary had a serviceable 8cm QF field gun (the M5/8), and a mixture of field guns, field howitzers, heavy field artillery, mountain artillery and horse artillery. Each infantry division had a field artillery brigade consisting of two field artillery regiments, two heavy field regiments, and a mountain artillery battalion. A field artillery regiment *(Feldkanonenregiment)* consisted of two battalions, each having two batteries of 6 guns. In total the Army fielded 397 field batteries and 74 mountain batteries, with 1,934 field guns and 628 howitzers.

Opening campaigns

Schlieffen had relied in his pre-war planning upon slow Russian mobilization. The Germans were prepared to give ground in an 'elastic defence' of East Prussia, simply containing an anticipated Russian attack, while the larger part of the German Army knocked France out of the war; most of these units would then return swiftly across Germany via the excellent railway network, to finish off the Russians. As expected, the Russians attacked into East Prussia, while Austria-Hungary moved against Serbia and Russian Poland. After a somewhat shaky start, and despite the failure to achieve a quick victory in the West, the German defence held and defeated the Russian attack. Tannenberg (26–31 August 1914) was a catastrophic defeat for the Russians, costing them 125,000 men and 500 artillery pieces, and the First Battle of the Masurian Lakes (9–14 September) cost them the same number of casualties and another 150 guns.

German soldiers on the Eastern Front examine a captured Russian 76.2mm M1902 field gun, presumably overrun after part of the horse-team was killed. The crew's Mosin-Nagant rifles are stuck in the ground by their fixed bayonets. (IWM Q86982)

Austro-Hungarian forces invaded Serbia and captured Belgrade, but

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In Romania, the German-Bulgarian-Ottoman Army Group Mackensen was obliged to support Austro-Hungarian forces from autumn 1916; they counter-attacked into western Wallachia in September, and captured Bucharest on 6 December. This German foot artillery *21cm Mörser* was photographed on a wooden gun platform in the hills at Predeal. The heavy wooden 'shoes' attached to prevent its wheels sinking into the ground emphasize the difficulty encountered by all armies on all fronts in moving heavy artillery over bad roads. (IWM Q55205)

were then driven out by the Serbs. Their attack on Russian Poland also ended in defeat, requiring assistance from the Germans in the form of operations in Western Poland, where poorly-led Russian armies were outfought by smaller German formations. By November 1914 Gen Paul von Hindenburg was in command of the combined Austro-German Eastern Front, and the battle of Łódź (11–25 November 1914) removed any Russian threat to invade Germany.

Blocked in the West, the Central Powers attacked in the East in 1915, but Austria-Hungary soon required more German support. The Germans made the first (and unnoticed) use of poison gas at Bolimov on 31 January 1915. Russian advances were checked in late spring, followed by an offensive by the Central Powers that saw the recently formed German Eleventh Army strike the Russian Third Army between Gorlice and Tarnów. Warsaw was taken in August, and the Russians were soon in full retreat.

1917: Toboly

On the Eastern Front the lines were, of necessity, thinly held – in 1916 a German division in the East might be responsible for a 30km sector, perhaps ten times its frontage on the Western Front. The battle space was so different from the West that direct comparisons between the number of guns per kilometre of front are misleading. Indeed, the nature of the Eastern Front meant that it was often possible for the Germans to take artillery from quiet sectors and mass it for maximum effect where an attack was planned, achieving local ratios of guns-to-infantry that were considerably higher than those found in the West. For example, the attack on the Russian bridgehead

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INFILTRATION TACTICS & TRENCH MORTARS, 1917

Although most closely associated with the German *Stosstruppen* units, effective small-unit 'infiltration tactics' were in fact developed by all the combatant armies and employed for raiding operations. The key difference was the German adoption of these infantry tactics as a standard method of attack, effectively co-ordinated with supporting arms including artillery and engineers. These illustrations are simply representative, but we borrow some features from the Jakobsbrunnen (Jacob's Well) raid in Lorraine in November 1917, undertaken by some 200 German infantry and pioneers to test the mettle of American troops.

(1) Opening bombardment The German guns have previously been registered on their targets whilst disguised among harassing fire, so as not to draw attention to the objective. To maintain the element of surprise the artillery preparation is unleashed only at the last possible moment, as the small units of raiders **(R)** are moving to cross their start line in No Man's Land. Gas and HE shells fall on the mortar pits **(MP)** behind the Allied front-line trenches, but only shrapnel and HE shells along the front line **(FL)**, so that the attackers will not encounter residual gas when they break into their objective. This gun barrage is thickened up with more precise fire from 17cm trench mortars **(TM).** Simultaneously, off the area of the illustration, other batteries are firing diversionary missions, and dropping HE and gas shells on Allied batteries, command posts and communication hubs to hamper any Allied response.

(2) The attack As the raiders reach the objective the artillery fire turns into a box barrage **(BB)** to seal it off from reinforcement or counter-attack. However, as they fight their way through the front-line trenches, mainly using grenades, the raiders still have the support of the heavy trench mortars sited behind their own trenches **(inset 1);** and they carry with them flamethrowers, and *Granatenwerfer* M1916 light mortars **(inset 2)**. It was recommended that the latter be used, preferably at oblique angles, against points where breaches were to be made. The raid is accompanied by signallers laying telephone wire behind them **(inset 3)**, enabling the leaders to report progress and to call in fire from the supporting artillery if required.

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Kneeling behind a limber, a Russian artilleryman sets the fuze of a shell while another looks on from a dugout crew shelter; this looks unimpressive, and proof against little more than bad weather. Bruchmüller's fire plans ensured that positions like this were suddenly enveloped in a hail of gas and HE shells. (IWM Q54748)

at Toboly by the 1st Landwehr Div in March 1917 was supported by 300 pieces of artillery and 100 *Minenwerfers*; by comparison, the average German division at Verdun was supported by 94 guns and 60 trench mortars. Barrages were also shorter and more intense – 5hrs 15min at Toboly, compared to 24 hours at Verdun. In a complex fire plan, field guns, field howitzers and *Minenwerfers* delivered the rolling barrage directly to the front of the advancing infantry. Heavy guns and howitzers provided both CB fire on the Russian artillery, and a box barrage to seal off the objectives from reinforcement.

The Bruchmüller method

The architect of the fire plan at Toboly was Georg Bruchmüller. A recently retired major in the foot artillery, Bruchmüller was recalled to active duty in 1914, initially to command the artillery at the Prussian fortress of Kulm, then as the artillery colonel of a Landwehr division before getting his own artillery regiment. Bruchmüller steadily gained a reputation as an outstanding artillery co-ordinator, who inspired such confidence in the units that he supported that his preparation for an attack was almost enough to guarantee success.

The keys to Col Bruchmüller's success were the effective use of neutralization; surprise; inter-arms co-operation; and massed firepower under centralized command. To grasp the difference between the two artillery effects of 'destruction' and 'neutralization' it is worth considering the current NATO definitions:

Destroy: Damage an object or an enemy force so that it is rendered useless to the enemy until reconstituted.

Neutralize: Render an enemy temporarily incapable of interfering with the operation.

Experience in the Russo-Japanese War had shown that when an artillery battery engaged another by counter-battery fire, it was very difficult to inflict more than superficial damage on heavy guns. If the crews removed their vulnerable gunsights and took cover in dugouts, then the chances were high that as soon as the enemy bombardment was over they could emerge and carry on firing.

Attempts to actually destroy a gun battery required enormous amounts of firepower; artillery was strictly an area weapon, and shells would spread over a 'zone'. To illustrate with the example of a single British QF 18-pdr firing at 3,000 yards: 50 per cent of the rounds fired would land in a rectangular zone 20 yards long by 1.44 yards wide, centred on the target. The remainder would fall around this zone, making an elliptical pattern 80 yards long by 5.76 yards wide. Thus a particularly unlucky gunner might have his first shot fall 30 yards short of the target and the second 10 yards beyond it; his third shot might land 8 yards to the target's front, and his fourth 40 yards beyond it.

At longer ranges, and in the case of howitzers with a higher trajectory, the zone would be significantly larger. Hence the attraction of using area munitions like shrapnel shells, and, conversely, of fitting guns with armoured shields that increased the probability of surviving artillery attack. However, although relatively unscathed, a battery under fire was unable to function,

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1917: German field artillery advancing upon Riga, the gun festooned with the crew's kit. General Bruchmüller's reputation was earned not only by his tactical skills, but by his operational vision in massing his artillery against his main objective while accepting the price that would probably have to be paid in other sectors. The nature of the fighting in the East allowed him this choice, which was unknown on the Western Front. (IWM Q86695)

and was therefore 'neutralized', and the same was true of troops dispersed or taking cover in trenches. Neutralization was relatively easy to achieve, but temporary; destruction was permanent, but relatively difficult to achieve.

In order to maintain surprise, Bruchmüller's neutralization fire missions were 'predicted', i.e. laid by map and other calculations rather than by firing registering shots on their targets before the operation (or, if they were registered, this was concealed by firing a deception-fire mission). To make up for the inevitable loss of accuracy, and to further enhance the effect, Bruchmüller massed his artillery and made extensive use of gas shells. His barrages were also of furious intensity, but relatively short in duration. On the Western Front the whole days of artillery preparation were often counter-productive; they signalled the imminence of an attack while simply churning the same mud repeatedly.

Bruchmüller explained to the infantry, including the NCO platoon leaders, exactly what his guns could and could not do. They would only ever destroy a portion of the enemy, but the entire enemy force would be neutralized until shortly after the barrage lifted. The key was for the infantry to stay close behind the rolling barrage – as close as 50m if possible. The enemy would find himself enveloped in a storm of exploding shells and poison gas that would last for several hours. As the barrage lifted, but before the dust had settled and with the smashed trenches still filled with gas, the battered survivors, gasping and half-blind in their gasmasks, would find themselves staring down the length of a German bayonet, or watching a grenade bouncing down the steps into their dugout. When assessing Bruchmüller's reputation, it is important to stress that he was not doing much that the Allied armies were not already doing on the Western Front. In the East, however, it was revolutionary, and his efforts to ensure that the infantry understood how to make the most of the support they would receive were a masterclass in inter-arms co-operation.

Riga: 'Hutier tactics'

After a series of actions of increasing scale and importance, Bruchmüller's finest moment on the Eastern Front came in September 1917, in the operation by Gen Oskar von Hutier's Eighth Army to capture the fortress city of Riga, Latvia, which anchored the northern end of the Russian front line on the coast.

The German plan involved crossing the Dvina river 30km east of Riga, where it looped south to form the Üxküll peninsula, and where three islands broke up the 350m width of the water obstacle. Hutier planned to build three pairs of pontoon bridges, from the south (German) bank to each of the

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While the German Army had to divert assets from the Western Front to bolster the Austro-Hungarians in the East, both Germany and the Entente powers had to send troops to support their faltering allies on the Italian front – respectively, Austria-Hungary and Italy. After the Italian collapse at Caporetto in October 1917 the first troops of British Second Army (which would peak at five divisions) arrived on the Piave front; here, in spring 1918, Allied senior officers are inspecting a British 26cwt 6in howitzer. The emplacement includes heavily sandbagged ammunition and crew shelters for protection against CB fire. (RAHT AL 1158 series)

islands, and then from the islands to the northern (Russian) bank. Each bridge would be the crossing-point for three divisions; once on the north shore the nine divisions would head west, to cut off Riga from the rear. Riga was a Russian bridgehead, with the majority of the Russian force occupying the south bank. Finding German forces behind them on what should have been the friendly bank would leave them effectively encircled.

At the chosen crossing-point there were Russian positions on the islands, three lines of Russian trenches on the north bank, and another two lines of trenches on high ground 4–5km further to the north. Bruchmüller massed a *Minenwerfer* brigade with 100 heavy, 130 medium, and 320 light pieces; directly answerable to him, this was tasked to suppress the nearest Russian positions. Behind the *Minenwerfers* were field guns and light field howitzers, which would bombard the Russian positions further inland with HE and gas, and fire barrages forming the left and right sides of a 'box' sealing off the crossing-point. Field guns would also cut the communication trenches leading to the Russian front line, while heavy artillery targeted vital points such as villages and crossroads. The German artillery, infantry and pioneers were massed south of the river under cover of thick woods.

The bombardment began at 0400hrs on 1 September 1917, and in the space of two hours 20,650 'blue cross' and 'green cross' gas shells (respectively, lethal diphosgene-plus-chloropicrin, and diphenylchloroarsine tear gas plus HE) fell on the Russian positions. At 0600hrs, further German artillery opened fire on a 120km front, with concentrations to support diversionary attacks on Russian positions south of the Dvina. At 0910hrs the first German infantry rushed through lanes cut in their barbed wire and dragged their assault boats into the river. The Russian defence was entirely suppressed by

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FRENCH 37mm INFANTRY GUN, 1917–18

The 'infantry gun' was a response to the increasing dislocation between the infantry and its traditional supporting arm, the field artillery. Initially, lightweight mountain guns and small field guns were used by German infantry units. In 1917 the French Army adopted the 37mm *Canon d'infanterie de 37 à tir rapide modèle 1916*, a purpose-built gun designed to be portable (238lb weight), simple to operate, and quick-firing. It proved particularly useful against targets such as concrete MG pillboxes that had survived a preparatory artillery barrage and were holding up an advance.

Typically the gun was issued on a scale of one or two per infantry battalion, depending upon the number of companies in the unit (four or six). It was served by a two-man crew supervised by an NCO *chef de pièce*, plus an ammunition corporal with four assistants. It was usually fired mounted on a shallow tripod, but it was issued complete with removable wheels, a folding gunshield, and a small one-horse ammunition limber. It could be used in either the direct or indirect fire roles.

(1) Typical use of 37mm Mle 16, with wheels and gunshield removed and the gunner and loader lying on the tripod mount. Note the large conical flash-hider at the muzzle; photos occasionally show this too removed in action. The gun was loaded with HE shells by hand, and a practised crew could keep up a rate of 12rpm; maximum range was about 2,000 metres.

(2) The gun detachment manhandling it across country at the orders of the NCO, who carries the folded gunshield; here the wheels have been left in the rear with the limber. The first two men carry the tripod, trail legs folded closed, at the point of balance. Two more, with sights and spares in cases on their belts, carry the barrel and recuperator by means of the sponge staff thrust down the barrel and out the open breach. The last three carry ammunition in 16-round boxes.

(3) Wheeled, shielded gun with horse and limber. This carried 14 ammo boxes, plus two chests for tools, spares and accessories.

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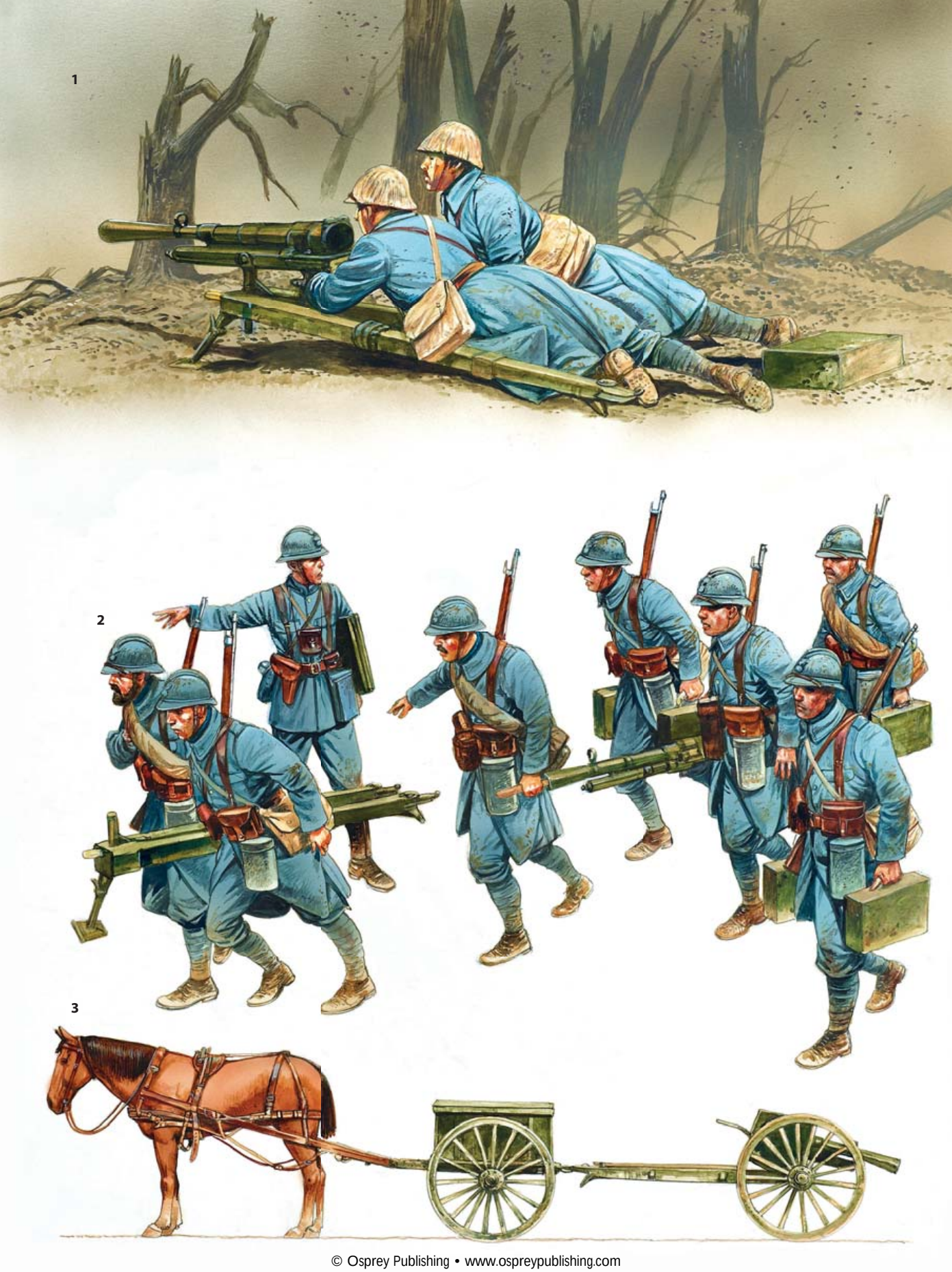

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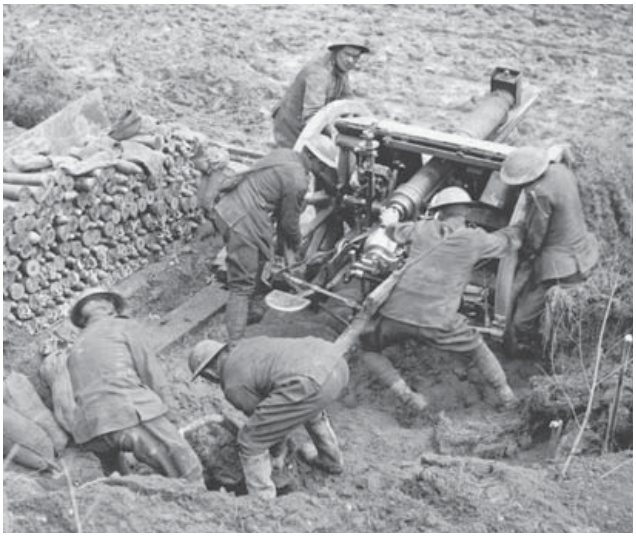

A RFA 18-pdr gun during the Battle of Arras, April 1917. The structure fitted to the front of the recuperator on top of the barrel is an armoured oil tank, to extend the life of the buffer spring. The previous autumn up to 35 per cent of the field artillery had been unserviceable at any one time due to the failure of these springs, but it was then realized that much could be achieved with correct maintenance and remedial action on the gun positions. Battery officers were given further training in maintenance, and the unserviceability rate dropped steadily, reaching 2 per cent at worst by the end of the war. (IWM Q5171)

the barrage, and the assault troops were able to reach the north bank without significant difficulty. There they fired green rockets, and the barrage began to roll north. Dazed Russian defenders were rounded up, the beachhead was quickly secured, and the attackers headed inland while the pioneers started to construct the pontoon bridges.

The crossing had been a masterpiece of artillery suppression, but it came at a price. The concentration of fire on the Üxküll peninsula left the remainder of the front dangerously short of artillery support, particularly counter-battery fire. German diversionary attacks were pummelled by Russian artillery – but instead of counter-attacking, the Russians retreated. Support for German troops on the north bank continued to be provided by the heavy artillery south of the river, although some light infantry guns had been taken across in the assault, and teams of artillerymen took over abandoned Russian guns on the north bank. By the close of the day six divisions had crossed the Dvina, and a further three – plus cavalry, artillery and logistic support – crossed the following day. Three days after the river crossing German troops were entering Riga. 'Hutier tactics' had been born: preservation of the element of surprise; short, violent bombardment; infiltration; and the use of smoke and gas to blind enemy strongpoints.

While the German encirclement was not finally completed (Hutier was ordered to halt, as troops were needed for the Western Front), nevertheless the Russian Twelfth Army was routed. Russia descended into chaos, the Bolsheviks seized power, and, on 15 December 1917, they signed an armistice with Germany: Russia was out of the war.

The way in which the artillery support to the Riga operation was organized – such as the allocation of targets to means, and the choice of ammunition natures for particular tasks – demonstrates why Bruchmüller earned such a remarkable reputation. On the Eastern Front, he had the advantage of a declining enemy and the opportunity to mass more artillery than was possible on most other fronts, but he was undoubtedly an outstanding leader and a great artilleryman. He took what was available in the military science of his time and lifted it to the level of an art; he had a 'feel' for the battlefield, and an instinctive ability to know where and when to apply his artillery.

1917: THE WESTERN FRONT

Withdrawal to the Hindenburg Line

In spring 1917 German forces, weakened in the meat-grinder on the Somme, were withdrawn to a new defensive 'Hindenburg Line'. This was some 30km (*c.*20 miles) to the rear of the existing front line, and was designed to be held by fewer troops, leaving more available to form a mobile reserve. Three layers

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of defences were spaced so that each lay beyond artillery range of the preceding one. As each layer was taken, the attackers would be forced to reorganize on the objective and move their artillery forward before they could attempt the next, thus giving German reserves time to counter-attack. The Germans completed their withdrawal eastward by 5 April 1917. They deliberately left utter devastation behind them, and the clearest sign that they were abandoning a particular sector was the smoke from burning villages behind their former lines. Allied cavalry and cyclists were sent forward, supported by horse and field artillery, but the appalling state of the ground, the blown bridges, and determined German rearguards made the advance a slow business – further hindered by the logistic challenges of supplying troops on the far side of two sets of trenches and the devastated waste of the old No Man's Land.

The day after the withdrawal was completed, the United States declared war on Germany. On joining the Entente powers America started the enormous task of creating a million-man army, which was intended to be deployed in Europe by May 1918.

Arras

In December 1916, Joffre was replaced as C-in-C by Gen Robert Nivelle. Command relationships between the British and French became difficult, while the overconfident Nivelle openly boasted about his forthcoming offensive. The overture to this was an attack by the British First and Third Armies at Arras on 9 April.

After a strong start the operation ground to a halt, as logistic support and forward momentum were stifled by mud and destruction. However, the Canadian Corps triumphantly took the dominating Vimy Ridge, and the attack thrust deep into the German defences. It was at just this time that Bruchmüller was making his reputation in the East – but many British artillerists, analysing the performance of the various artilleries post-war, were convinced that at Arras the British artillery practice was significantly more advanced than the German. In the period since the start of the Battle of the Somme the British artillery had been transformed. Welded into a new type of force, it was artillery on the grand scale, but it was now far from being simply a blunt instrument to bludgeon the enemy by weight of fire.

Command and control was now far more sophisticated; new links had been forged in the chain of command leading from the General Officer Commanding Royal Artillery (GOCRA), who had ultimate authority over each army's guns, right down to the individual batteries. The staff structure was greatly improved, and communications were more reliable and comprehensive. A vast telephone network of land lines, buried to protect them from direct hits, connected OPs, batteries, headquarters, and all the many other installations. Wireless (radio) was still unreliable – the sets were heavy, and the process of encoding messages slow; nevertheless, two 'Trench Wireless Sets' were issued to each infantry division (in addition to large numbers of carrier pigeons). Observation officers were sent forward with the infantry to set up OPs on higher ground, communicating back to the guns through a series of relay posts.

Doctrine had been formalized; standard procedures were now observed across all the divisions, with only minor variations for the nature of the ground and the enemy defences. The creeping barrage was standard, starting in front of the foremost line of enemy trenches and typically lifting 100 yards every 3 minutes – as were stationary or 'standing' barrages, which jumped forward to the next line of defences when the creeping barrage reached them.

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Trench mortars and RE gas mortars, Livens Projectors and gas cylinders were incorporated into the fire-planning, which also included extensive use of gas shells by the artillery. The battlefield was no longer littered with unexploded British ordnance; the quality of product from the National Shell Factories had greatly improved, and the introduction of the No. 106 'Instantaneous' fuze was also making a dramatic difference to the effectiveness (and safety) of British HE shells.

No effort was spared to gain total ascendancy over the German artillery by destroying any batteries that could be located by the now highly effective flash-spotting, sound-ranging and aerial reconnaissance. Interdiction fire struck key junctions, depots, HQs, forming-up points and other depth targets. Each type of gun or howitzer was used in the manner that best suited its characteristics, and arrangements were in hand to attempt moving even heavy 6in howitzers and 60-pdr guns forward to engage new targets as the infantry captured each objective. (In the event, however, in 1917 this was thwarted by the condition of the ground, and at Arras attacks beyond the first line failed due to the lack of artillery support.)

The detailed artillery plan issued for the Battle of Arras directed the Canadian Corps to divide their heavy artillery into three counter-battery groups plus eight 'siege' groups to destroy the enemy defences, while British I Corps was to organize three CB groups and two siege groups. The CB groups had 60-pdr and 4.7in guns, reinforced with a 4.5in howitzer battery, and one (or more) heavy or medium howitzer batteries, which were to be used solely to engage enemy artillery – counter-battery took precedence over siege work. A distinction was drawn between CB operations more than ten days before 'Zero', during those ten days, and on 'Zero Day' itself. During the first period, continuous CB work aimed to destroy every battery that had been located, regardless of the amount of ammunition required. During the ten days preceding Zero, CB fire aimed to destroy isolated batteries, since they were the hardest to neutralize on the day itself, with grouped batteries being engaged towards the end of the period.

At the last moment enemy telephone exchanges would be targeted, as

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CAQUOT TYPE R OBSERVATION BALLOON, US ARMY CORPS OF SIGNALS, 1918

'Kite' balloons were widely employed by all combatant armies after the war entered its static phase, and the first British detachment was deployed in May 1915. Early round or sausage-shaped designs were unstable in high winds, and were soon replaced by Capt Albert Caquot's superior French design, which featured three stabilizing fins and an innovative arrangement of internal cells. The Caquot Type M saw widespread use by the Allies, and nearly 1,000 very similar Caquot Type Rs were manufactured in the USA. The Type M was 82ft (25m) long and 26ft 8in (8.15m) in diameter at its widest, with a volume of 32,840cu ft (930cu m), filled with highly flammable hydrogen gas.

Normal operating altitudes were between 1,000ft and 4,000ft (300–1200 metres). Although balloons were initially used for general observation, as the war progressed they became increasingly associated with spotting for long-range artillery fire and counter-battery work. At maximum altitude the observers could see as far as 50 miles (80km), but a circle of 6.5 miles (10km) was the normal area of observation. The two-man crew **(1)** were equipped with a large map board, an airspeed indicator and barometer, two pairs of binoculars and two telephone handsets; the telephone line passed down the tether cable to the winch truck **(2)**, allowing two-way voice communication. In 1916 a relatively lightweight wireless telegraphy (W/T) transmitter was introduced, and late that year a Central Wireless Station was established; but, as with aircraft, this was only one-way Morse communication, since no airborne receiver would be available for years to come. Telephone communication made balloons a much more effective platform for observation and fire-direction than contemporary aircraft, and, as important targets for enemy aircraft, they were usually well protected by AA guns.

Under attack, the two observers could hasten the balloon's winched descent by venting gas from the envelope, but if the hydrogen was ignited by incendiary MG ammunition or rockets their only hope was to jump, using the parachutes stowed in bags on the outside of the basket.

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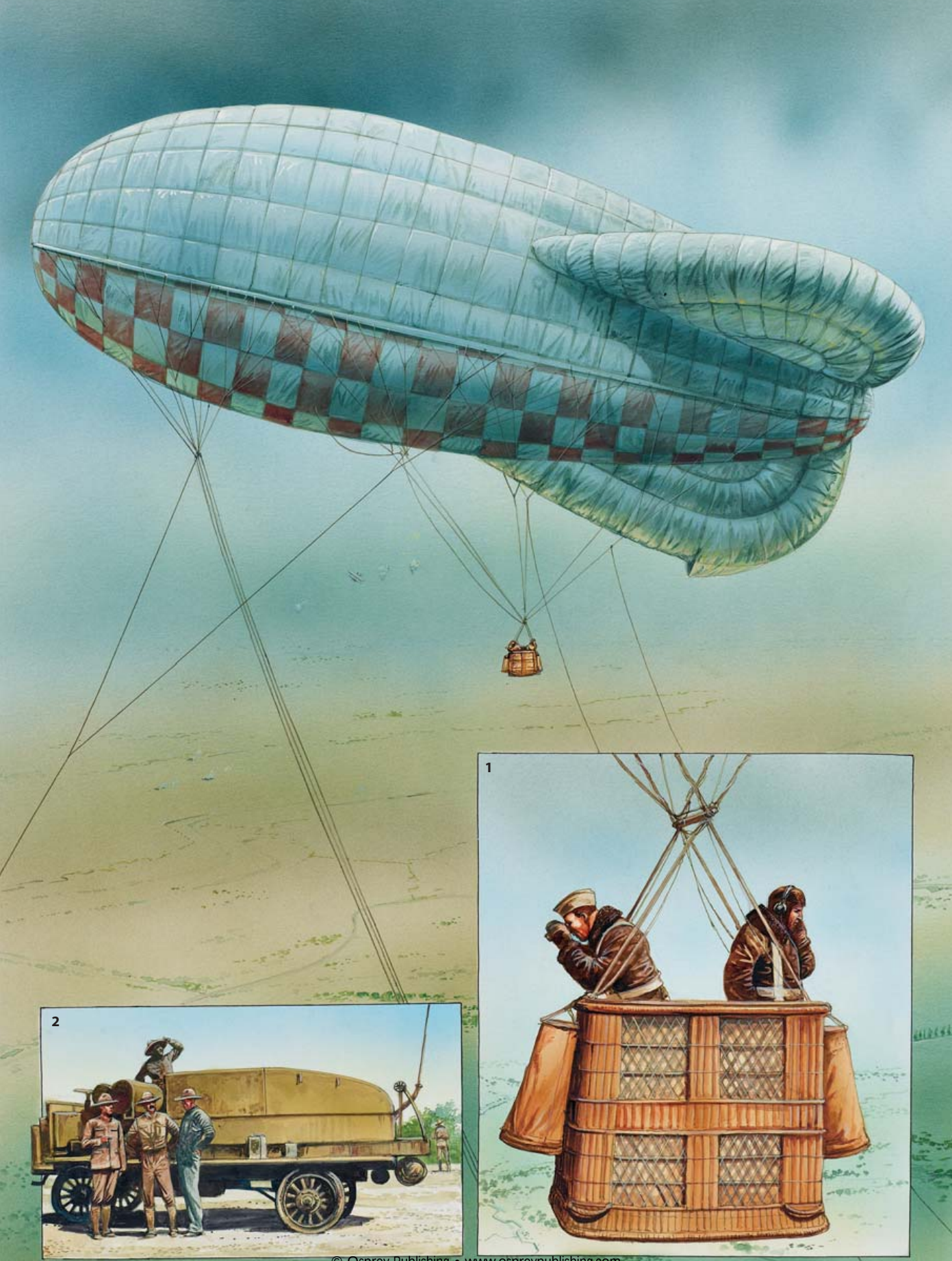

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BARRAGE TABLE FOR No. 1 GUN.

DATE..... BATTERY R.F.A.

All information on this Table is corrected for this individual gun. No. 1 will not apply gun corrections.

Barrage.	Time. From	Time. To	Angle.	A. of S.	Gun elevation.	Last correction if necessary.	Ammunition. Shell.	Ammunition. Propellant.	Fuze. Nature	Fuze. Corrector.	Rate of Fire. Rate p.g. p.m.	Approximate No. of rounds.	Remarks.
1	0	4	6°20′ L	+5′	3225		H.E.	Cordite	101 delay	–	4	16	
2	4	8	6°L	,,	3325		,,	,,	,,	–	4	16	
3	8	10	5°40′ L	,,	3400		,,	,,	,,	–	4	8	
4	10	12	5°25′ L	,,	3425		,,	,,	,,	–	4	8	
5	12	16	5°5′ L	,,	3525		T.S.	,,	80	162	4	16	
6	16	20	4°45′ L	,,	3625		,,	,,	,,	,,	4	16	
7	20	24	4°25′ L	,,	3725		,,	,,	,,	,,	4	16	
8	24	28	4°5′ L	,,	3825		,,	,,	,,	,,	4	16	
9	28	58	3°55′ L	,,	3925		,,	,,	,,	,,	1	36	3 r.p.g. from 56
10	58	64	3°40′ L	+10′	4025		,,	,,	,,	,,	3	18	
11	64	70	3°30′ L	,,	4100		,,	,,	,,	,,	3	18	
12	70	76	3°20′ L	,,	4175		,,	,,	,,	,,	3	18	
13	76	136	3°10′ L	,,	4275		,,	,,	,,	,,	1	66	3 r.p.g. from 134
14	136	144	3°L	,,	4375		,,	,,	,,	,,	3	24	
15	144	148	2°50′ L	,,	4450		,,	,,	,,	,,	3	12	
16	148	152	2°50′ L	,,	4475		,,	,,	,,	,,	3	12	
17	152	160	2°45′ L	,,	4550		,,	,,	,,	,,	3	24	
18	160	164	2°40′ L	,,	4600		,,	,,	,,	,,	3	12	
19	164	168	2°30′ L	,,	4650		,,	,,	,,	,,	3	12	
20	168	172	2°20′ L	,,	4725		,,	,,	,,	,,	3	12	
21	172	176	2°10′ L	,,	4850		,,	,,	,,	,,	3	12	
22	176	210	2°L	,,	4975		,,	,,	,,	,,	1	30	3 r.p.g. from 208
23	210	216	1°40′ L	+5′	5100		,,	,,	,,	,,	3	18	
24	216	–	1°15′ L	,,	5225		,,	,,	,,	,,	–	–	

The atmospheric corrections for range in Table II. and for line in Table III. should be calculated as shortly before zero hour as is compatible with the time required for the preparation of time fuzes, etc.

Should any final alterations of elevation or line be required after the barrage table for each gun has been made out, the amount of alteration required and final elevation should be entered in Columns 7 and 8.

ABOVE The painstaking sophistication of British artillery tactics from 1917 surpassed that of the German Army. This is a representative barrage table from *Notes on Gunnery* (May 1918) for a single QF 18-pdr gun firing as part of a barrage. A table such as this would be prepared in advance for every individual gun. It gives the exact laying of the gun for line and elevation, the ammunition and fuzes to be employed, and the rates of fire, 'lift by lift' throughout a barrage lasting 3 hours 36 minutes. (Author's collection)

OPPOSITE A representative barrage table for a six-gun battery of 18-pdrs, from the same source. The left-to-right columns show the corrections to be made to the laying of each of the six guns (allowing for their individual degree of wear), the ammunition used, and the meteorological conditions, as the barrage falls on the successive German 'Red', 'Blue', 'Green' and 'Brown' defensive lines. There is a note that No. 4 Gun is to fire smoke shell throughout. (Author's collection)

would be their OPs (or blinded with smoke shells, if destroying them proved too difficult). The response times for German artillery were known, batteries taking perhaps 6 minutes to open their defensive barrage. Therefore, at Zero-hour +5 minutes all available guns (including siege artillery that had finished their bombardment of enemy trenches) opened fire on known German battery locations, with the intention of neutralizing the German artillery for 15 minutes. At the end of this period, destructive fire was resumed as the opportunity presented. This remorseless hammering of counter-battery fire wore down the German artillery to the extent that, by 6 April, the German 11th Div (for example) no longer possessed a single battery at full strength.

It will be apparent that the British were pursuing a different approach to that of the Germans on the Eastern Front, where the rather shaky Russian artillery was neutralized by firing large numbers of gas shells. Even so, the Germans found they had to increase the proportion of HE shells to gas from 10 per cent to 50 per cent in order to ensure that offensive operations could continue without interruption from the Russian guns. For the British, mere neutralization of German batteries was inadequate; CB fire to destroy them, at any cost in resources, was regarded as fundamental to the success of any attack.

The other important difference was in the creeping barrage, beginning in No Man's Land and moving slowly forward in a series of 100-yard lifts. At this stage the Germans were still trying to make their equivalent, the *'Feuerwalze'*, work with two 100m lifts followed by a series of 50m lifts. Although some British divisional artilleries used 50-yard lifts at Arras, planners were increasingly of the opinion that this distance was too short, and the Germans also subsequently abandoned it.

The Nivelle Offensive

On 16 April 1917 Gen Nivelle attacked, pitting 1.2 million French troops and 7,000 guns and mortars of the Fifth and Sixth armies against the First and Seventh German armies holding the front between Soissons and Reims. French security had been severely compromised, and the Germans were waiting; they had virtually emptied their front line, and denied the French air force the necessary freedom to spot for the artillery. The French barrage fell mostly on empty trenches; when the assault went in German guns tore into the French infantry, and destroyed French tanks before they could even deploy. Despite the rolling barrage 'getting away' from the infantry, the French managed to take the first line of German defences, but got no further – at a cost of 120,000 casualties. After the tragic heroism of Verdun, the disappointment of this failure on the Chemin des Dames was too much. French morale collapsed; the first mutinies broke out on 29 April, and for

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perhaps two weeks the French Army ceased to be an effective fighting force.

TABLE II.

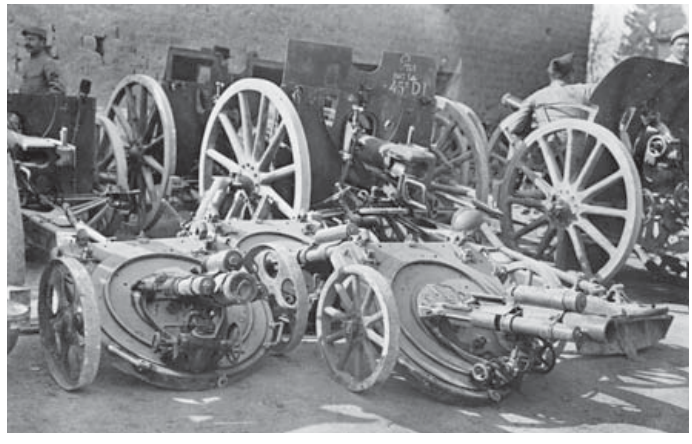
No.	Cordite M.V.	Initial mag range.	Position correction.	Ammunition correction *	Gun correction.	Atmospheric correction (Variations observe temp.)	Opening elevation.	Add to RED LINE.	Ammunition correction. †	RED LINE ELEVATION.	Add to BLUE LINE.	Additional gun correction.	BLUE LINE ELEVATION	Add to GREEN LINE.	GREEN LINE ELEVATION.	Add to BROWN LINE.	Additional atmospheric correction.	BROWN LINE ELEVATION.
6	1600	3225	–	– 25	+ 25	+ 50	3275	+675	+ 25	3975	+325	+ 25	4325	+675	5000	+225	+ 25	5250
5	1630	3225	–	– 25	– 25	+ 50	3225	+675	+ 25	3975	+325	+ 25	4275	+675	4950	+225	+ 25	5200
4	1570	3225	+25	‡Smoke	+100	+ 50	3400	+675	Smoke	4075	+325	+ 25	4425	+675	5100	+225	+ 25	5350
3	1610	3200	–	– 25	–	+ 50	3225	+675	+ 25	3925	+325	+ 25	4275	+700	4975	+225	+ 25	5225
2	1590	3200	–	– 25	+ 50	+ 50	3275	+675	+ 25	3975	+325	+ 25	4325	+700	5025	+225	+ 25	5275
1	1610	3200	–	– 25	–	+ 50	3225	+675	+ 25	3925	+325	+ 25	4275	+700	4975	+225	+ 25	5225

* H.E. delay.
‡ No. 4 gun is shown as firing smoke shell throughout. To obtain good distribution, unless there is a cross wind, 1 round of smoke shell per gun should be fired every so many minutes.
† Change from H.E. delay to T.S. after 3500x.
Should a change of propellant occur, allowance for this must be made.

Messines

By the Battle of Messines (7 June 1917) British artillery on the Western Front was operating with unmatched efficiency. Its methods were scientific, careful staff planning dominated, and the amount of artillery required for different tasks was now the product of calculation. The requirements for counter-battery work were based on an accurate assessment of the number of German guns within 9,000 yards of the area of the attack (a figure calculated by the Second Army artillery staff was then increased by 100 guns by the highly experienced MajGen Birch). Requirements for the 17-day preparatory bombardment were based on one medium gun or heavy howitzer per 45 yards of front – approximately the same proportion that had been used at Vimy Ridge, and calculated in the following way. A battery of 4 howitzers could occupy a lane 180 yards wide, and it was calculated that such a lane, 3,000 yards deep, would contain an average of 2,700 yards of trenches. The battery, firing 800 rounds per day, would fire 4,000 rounds in five days, or 1.5 rounds per yard of trench, which was considered an 'adequate' bombardment. Therefore the requirement was for one howitzer per 45 yards of front (one-quarter of 180 yards).

Some heavy howitzers were even pushed right forward, to allow the firing of 'back barrages' and long-range CB fire into the German rear, and long-range Vickers MG indirect fire was integrated with the barrages – another innovation that had worked at Vimy. At Messines careful planning, and the detonation of mines under the German positions, resulted in a considerable success. It was marred only by a number of 'friendly fire' incidents as British troops consolidated after the battle; these were due to poor communications, and the challenge of adapting to a more mobile style of warfare as British troops pushed into the deep German defensive zones.



April 1917: German field guns and trench mortars captured by French troops at Monvilliers. The bulky *Minenwerfer* mountings, with removable wheels for transport, are very apparent. Although a few more basic *ersatz* designs did see service, the German Army remained wedded to the complex and expensive *Minenwerfer* as a miniature siege artillery piece throughout the war. (IWM Q47945)

Third Ypres (Passchendaele)

Third Ypres (31 July–10 November 1917) saw Gough's British Fifth Army, supported on the left by the French First Army and on the right by Plumer's British Second Army, confronting the German Fourth Army in strong, in-depth defensive positions characterized by concrete pillboxes in an otherwise thinly held first line. Advancing over appallingly sodden, shell-churned ground, Gough's attack became bogged

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down by the deep mud and determined defence. After Plumer was placed in command on 25 August, carefully prepared limited attacks resulted in the eventual capture of Passchendaele Ridge on 6 November. This deepened the salient the British had driven into the German defences, and continued to distract the Germans from the weakened French Army – though only at the horrific cost of more than 320,000 British casualties. The battle was notable as the last to feature a great set-piece preparatory bombardment:

British artillery ammunition expended, Third Ypres,15 July–2 August 1917	
Gun/howitzer	*Rounds expended*
18-pdr gun	2,239,608
4.5in howitzer	728,345
60-pdr gun	255,462
6in gun	21,354
6in howitzer	750,119
8in howitzer	165,975
9.2in howitzer	113,073
12in howitzer	8,008
15in howitzer	1,606
Total:	**4,283,550**

British artillery deployed, Western Front 1916–1917					
Battle	*Frontage (miles)*	*Heavy artillery*	*Medium artillery*	*Field artillery*	*Ammunition expended*
Somme 1916	14	143	284	1,010	1,732,873
Arras 1917	13	301	663	1,854	2,687,873
Messines 1917	9	236	504	1,510	3,258,000
Third Ypres 1917	15	281	718	2,092	4,283,550

Cambrai

The Battle of Cambrai (20 November–3 December 1917) is recognized as a turning-point on the Western Front, which featured a short preliminary bombardment and the effective use of tanks – at least in the earlier stages of the battle. In the absence of his corps artillery commander, the artillery plan for Cambrai was the work of BrigGen Hugh Tudor, the CRA of 9th (Scottish) Division. Tudor persuaded his superiors to accept the omission of the long preparatory bombardment which had previously been considered vital for the success of a major attack. Cambrai is sometimes compared with the Battle of Riga on the Eastern Front. Both involved forces of approximately the same size – eight German divisions, plus five in reserve, at Riga, and eight British divisions, plus three in reserve, at Cambrai. Both were attacks on well-prepared defences; and both used tactics that would come to be seen as the future of land warfare. Tudor's plan, like Bruchmüller's, depended on the use of predicted fire to achieve surprise, but there were some significant differences between British and German practice.

April 1917: gunners taking their ease in a German 15cm heavy field howitzer battery position in a sunken road near Arras. The 60cm-gauge tramlines in the foreground enabled ammunition to be delivered directly to the guns. (IWM Q42433)

The Germans could predict fire with reasonable accuracy for line, but

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struggled to achieve accurate range, which is why they suppressed within rectangular area targets, and used considerable amounts of gas. The British also used gas to suppress enemy artillery – but because of accurate survey, 'meteor telegrams', and the calibration of each gun, British predicted CB and interdiction fire was significantly more accurate. The British barrage used both shrapnel and smoke; shrapnel was particularly effective for a creeping barrage since it was highly directional (i.e. the shellbursts threw the shrapnel balls forward towards the enemy), whereas HE/fragmentation burst in a circular pattern. The Germans lagged behind in the introduction of smoke shells, which were a vital component of the British barrage.

The surprise barrage, accurate and effective CB fire, and the use of hundreds of tanks enabled the British to penetrate 5 miles into the Hindenburg Line across a 6-mile frontage; but, yet again, the breakthrough was thwarted after a promising start, and fierce German counter-attacks subsequently forced Haig to partially withdraw from the salient. Nevertheless, the potential of attacks without lengthy preparatory fire, with a violent and accurate surprise barrage, and with infantry and massed tanks in co-operation, set the template for Allied all-arms warfare on the Western Front for the remainder of the war.

Instruction on the *7.58cm leicht Minenwerfer alter Art* ('light mortar, old model') at the German infantry training school at Sedan, 1917. (IWM Q55018)

1918: ENDGAME ON THE WESTERN FRONT

After the Russian collapse it was obvious that large numbers of German troops released from operations in the East would be used for a last-gasp offensive to try to break the Allies on the Western Front before the American Expeditionary Force joined the struggle in any numbers. Among them, Gen von Hutier, Bruchmüller (who was now the equivalent of a British MGRA), and other staff officers were transferred westward as part of the new German Eighteenth Army.

Crew posing with 'Dora', a 9.2in siege howitzer of 154th Siege Battery, RGA, on the Western Front in July 1917. (RAHT AL 1136 series)

As planning started for Germany's final roll of the dice, Bruchmüller's advocacy of predicted fire for barrages met with resistance from experienced officers in France, who discounted opinions formed by what they believed to be the much easier conditions in the East. Bruchmüller also favoured centralized control of artillery at corps level, as used by the British, whereas the German Army in the West had devolved control to divisional level to make artillery more responsive.

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Battle of the Aisne, May 1918: during the third phase of the German offensive, heavily laden German troops drag their trench mortars across captured British front-line trenches near Berry-au-Bac. (IWM Q29899)

There was, however, an appetite for a new approach in the West, and Hutier's attacking style and Bruchmüller's use of massed artillery under centralized command won the senior backing required to start training programmes across the Western Front.

Nevertheless, it is evident that technically the German artillery was lagging behind the Allies, especially the British. It was only during 1917 that the Germans began experimenting with techniques to calibrate guns for barrel wear, and allowing for variations in temperature, barometric pressure and the characteristics of different batches of propellant, and (as noted) as late as February 1918 the idea of using predicted fire based on these techniques was strongly resisted by the high command. As a result, inconsistent doctrine was applied across the German artillery when the offensive finally began.

The *Kaiserschlacht*

When the storm broke on 21 March 1918, some 6,000 German guns and mortars fired over 3 million shells as the Seventeenth, Second and Eighteenth German armies, attacking in thick fog, struck the British Third and Fifth armies along a 60-mile front from Arras to La Fère. The idea was to drive a wedge between the British and French, rolling up the British from the south. In Bruchmüller's sector (Hutier's Eighteenth Army) the artillery fired a predicted barrage, while in the Seventeenth Army area Gen von Berendt's artillery fired on registered targets. The Eighteenth Army's infiltration-led attacks advanced further, but, as there were significant differences in the strength of the opposition between the two sectors, credit for this cannot be given entirely to Hutier's tactics and Bruchmüller's artillery techniques.

Gough's overstretched Fifth Army on the British right flank collapsed, and by the time the offensive was finally halted in April the Germans had achieved what the Allies had always failed to accomplish – a successful attack that punctured the enemy's defences and created a 40 mile-deep salient. However, logistic support was a nightmare; it also proved extremely difficult to move German artillery forward, with the result that the attack outran its support.

The Germans then attacked the British to the north in Flanders, where Fourth Army used 'Hutier tactics' to threaten the Channel ports. Haig rallied the British with his 'backs to the wall' order, and by 29 April the Germans were halted after a 10-mile advance. The third German offensive, between the River Oise and Reims in May, reached Château-Thierry, where the AEF acquitted itself well.

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German offensives further south during June and July gained tactical successes but were strategic failures. The quality of the German divisions was very variable, and after the spearheads had spent themselves all these attacks ran out of momentum. The Allies' cohesion held, and they were able to plan and gather for their counterstroke, bolstered by fresh American divisions flooding to the front. The Second Battle of the Marne (18 July–August) marked the turn of the tide, and thereafter the Allies started to roll back the Germans, operating effectively under a firm unified command headed from 14 April by Gen Ferdinand Foch.

Amiens

On 8 August the British Fourth and French First armies hit the German Eighteenth and Second armies in a surprise attack. Australians and Canadians of Fourth Army attacked under cover of fog and without preliminary bombardment; the French chose the more traditional method, using 39 batteries of French and Italian 75mm guns and 14 batteries of 155mm guns. All the techniques of combined-arms operations were in place, including deception, tight security, and the effective co-ordination of infantry, artillery and 400 tanks, under close air support.

There were no trenches to serve as jumping-off points, and the German positions were masked by standing crops. Many German infantry and artillery positions were in scattered woods and standing villages, which were a challenge for the infantry, and difficult targets for British artillery operating on the move in unfamiliar terrain. But the German Army was now in terminal decline; by the end of the battle 15,000 prisoners had been captured along with 400 German guns. The German chief-of-staff Ludendorff described 8 August as a 'black day', and said 'the war must be ended.' Three months later, it was, without the German Army ever finding a way to halt the Allies' 'Hundred Days' advance.

CONCLUSIONS

In 1914 the war had started with gallant but frequently futile battery actions recalling 19th-century warfare. In 1915–16, stunned by the awesome power of industrial-age artillery, the generals on both sides became convinced that if they could only get enough shells, nothing could stand in the way of a sufficiently huge bombardment. Verdun and the Somme proved them wrong; whatever the almost unimaginable scale of the carnage, artillery alone could not ensure a breakthrough victory. The year 1917 witnessed the arrival of the 'deep battle' – three-dimensional warfare, above and below ground and in the air, and across the divisions of 'deep', 'close' and 'rear'. A flood of information on the enemy was now flowing in from diverse sources of intelligence. The successful outcome of a battle demanded control of the air, efficient logistics, effective communications and liaison, and the co-ordination of artillery to neutralize the enemy in intimate support of imaginatively deployed infantry and tanks. These principles were perfected in the campaigns of 1918.

The most prominent name to emerge from this revolution was Georg Bruchmüller, translations of whose two books ensured his immortality. It should be apparent, however, that many of the innovations Bruchmüller was promoting were already in use elsewhere, and that in many respects the British artillery of 1917 was closer to Bruchmüller's ideal than was his own. The advances in military science during 1914–18 were the result of powerful evolutionary forces, which punished mistakes and rewarded success. Men like Bruchmüller, Birch and Tudor might not have been military geniuses, but they shared the invaluable ability to learn from, and then apply, experience.

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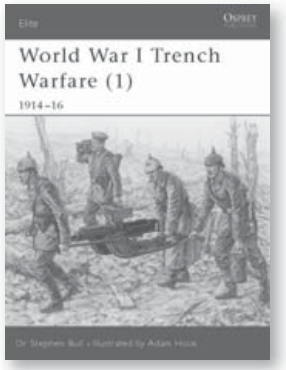

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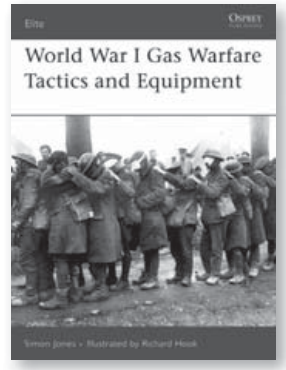

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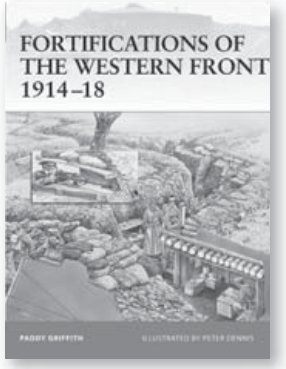

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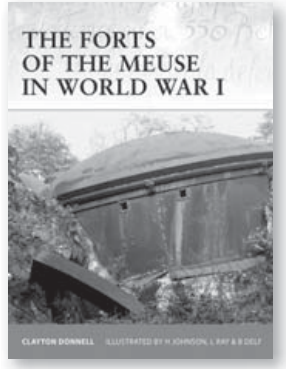

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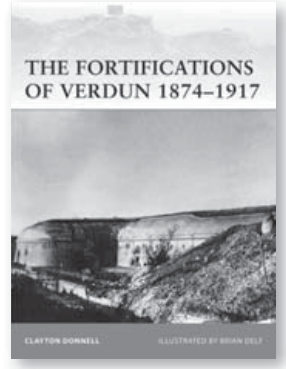

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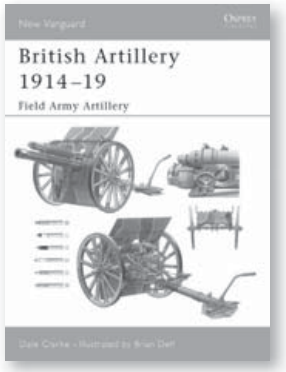

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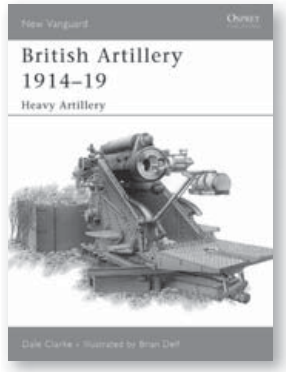

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FRONT COVER A British Mk V 8-inch howitzer in action near Wagonlieu on 12 May 1916, sending a 200lb (90kg) HE shell out to a range of up to 10,500 yards – nearly 6 miles (9.5km). During the early stages of the Battle of the Somme the following month, 64 of these pieces would be among more than 1,400 guns and howitzers that delivered the seven-day preparatory bombardment. (IWM Q569)

AUTHOR'S NOTE

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feet to metres	multiply feet by 0.3048
yards to metres	multiply yards by 0.9144
miles to kilometres	multiply miles by 1.6093
pounds to kilograms	multiply pounds by 0.4536
centimetres/millimetres to inches	multiply centimetres/ millimetres by 0.039/0.394
metres to feet/yards	multiply metres by 39.4/1.094
kilometres to miles	multiply kilometres by 0.6214
kilograms to pounds	multiply kilograms by 2.205

Acronyms used in this text:

AEF	American Expeditionary Force
BEF	British Expeditionary Force
BL	breech-loading
CB	counter-battery
CRA	Commander Royal Artillery (at division)
FO	forward observer
GOCRA	General Officer Commanding Royal Artillery (at army)
HE	high explosive
MGRA	Major-General Royal Artillery (at army)
QF	quick-firing
RA	Royal Artillery
RE	Royal Engineers
RFA	Royal Field Artillery
RFC	Royal Flying Corps
RGA	Royal Garrison Artillery
RHA	Royal Horse Artillery